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AN
ATTEMPT
TO ESTABLISH
A PURE SCIENTIFIC SYSTEM
OF
MINERALOGY,
BY THE APPLICATION
OF THE
ELECTRO-CHEMICAL THEORY
AND THE
CHEMICAL PROPORTIONS;

BY

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Translated from the Swedish Original

BY

JOHN BLACK.

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THE indefatigable industry, the uncommon precision, and the great number of new and important views with which the author of this little work has enriched Chemistry and the kindred Sciences, are sufficiently known, I presume, to all men of science in Great Britain, to induce them to receive every new proposal which comes from him with candour and attention. Professor Berzelius was obliging enough to send me a copy of the Original of this little Essay, immediately on its publication at Stockholm, about three months ago. On looking it over, it appeared to me highly deserving the attention of mineralogists, and likely, if properly followed up, to occasion a most important improvement in the method of analyzing minerals and in the scientific arrangement of them. I thought, therefore, that it would be conferring a considerable favour on the cultivators of that popular science, if an English translation of Professor Berzelius's Essay were laid before the public. My friend Mr. Black kindly undertook the task, stipulating only that I should compare his manuscript with the original, and take care that it everywhere conveyed its sense. This task I performed with all the requisite attention; and can, I think, answer with some confidence for the fidelity of the translation. The nature of the subject precluded all attempts at elegance of language; but I trust that the translation is every where perspicuous.

THOMAS THOMSON.

London,
Sept. 10, 1814.

SYSTEM OF MINERALOGY

FOUNDED ON THE

ELECTRO-CHEMICAL THEORY, &c.

The first system of mineralogy originated in the want felt by the collector of minerals of some kind of arrangement in his collection. This was at a period when the composition of few or no minerals was known, and it was natural therefore that the system should be altogether founded on arbitrary principles. In proportion as scientific information became more diffused, endeavours were made to advance mineralogy to an equality with other branches of knowledge. Linnæus endeavoured to arrange unorganized nature according to a classification analogous with that which he had so successfully applied to organized nature. Wallerius and Cronstedt began to perceive the influence which chemistry ought to have in every mineralogical arrangement; and now, since the late astonishing progress of chemistry has given it an additional claim to be considered as a science, its influence is so universally acknowledged that the two prevailing mineralogical schools of the present day, (Werner's and Haüy's,) both agree in the admission of chemistry to a participation in the foundation of a system of mineralogy, however much they may differ respecting the extent of that participation.

Mineralogy, in the usual acceptation of the word, is the science which treats of the combination between the unorganic elements which are found upon or beneath the surface of the earth, together with the various forms, and the different foreign admixtures, under which these bodies make their appearance.

The knowledge of the combinations themselves, their composition and chemical properties, belongs to chemistry; so that mineralogy, in a scientific point of view, may be considered as a part or appendage of chemistry.

Chemistry, considered as an entire and perfect science, makes us acquainted with the elements, with all the combinations of which they are susceptible, together with all the forms under which these combinations may make their appearance.

If we represent to ourselves chemistry in a state of perfection, subjected to a systematic arrangement, it must give us a description not only of the combinations which our investigations have discovered to be produced by nature, but it must also teach us all those which may hereafter be discovered as such, together with all those which are possible, though they never can make their appearance as fossils. This complete and perfect chemistry should, in the case of every combination, notice whether it appears as a mineral, and, if so, the different forms and shapes under which it is produced, the foreign ingredients by which it is usually rendered impure, or which may be mechanically blended with it; so that the province of chemistry extends beyond our laboratories to the great and astonishing workshop of nature.

Let us represent to ourselves a branch of this perfect chemistry containing all that relates to the combinations which appear as minerals. This branch is *mineralogy in its perfect state.*

It is beyond the limits of our feeble powers to bring any science to a state of perfection; for in that case all the sciences would be blended together into one. The quantity of knowledge however of which one man can make himself master is so circumscribed, that both from a regard to the imperfect state of the sciences, and the necessity of distributing them in such a manner that our whole species, taken together and considered as one individual, may possess all the acquisitions in every branch of science which one man can never do, we are reduced to the necessity of treating subjects belonging to the same department of knowledge under the form of separate sciences. This is no doubt the reason why mineralogy has always been considered as a separate science; but it is evident that it must go step for step with chemistry, and that every revolution in chemical doctrines must overturn those of mineralogy, in the same manner as the discoveries in the peculiar province of the latter must extend the boundaries of both.

Again, if mineralogy in itself is merely a branch of chemistry, it is clear that it can have no other scientific foundation for its arrangement than a chemical one, and that every other is altogether foreign to mineralogy as a science. The prevailing theory and arrangement therefore of chemistry for the time must be also that of mineralogy. If this has not always hitherto been the case, it must be attributed on the one hand to the recentness of the period during which chemistry has received its great improvements, and on the other to the circumstance that the framers of systems of mineralogy have not previously applied themselves with equal zeal and success to chemistry, and consequently have not been enabled to perceive the necessary connexion between them.

In the verbal disputations between the partisans of Werner and Haüy on the subject of the merits of their respective schools, the latter have often been asked if the mineralogist must always require the analysis of the chemist to enable him to examine a mineral? This question always distinguishes the collector of stones from the mineralogist. The former merely seeks a name for his minerals, while the latter endeavours to become acquainted with their nature.

The arrangement of minerals according to their external characters has not been so successful in facilitating our knowledge of them, as a similar arrangement has been in organised nature. In the latter we everywhere observe the greatest similarity of combination with the greatest diversity of form, and the character of the living body is derived from the form. But in inanimate nature we everywhere perceive the greatest similarity of external form under the greatest diversity of combination. The character of these bodies therefore altogether depends on the quality and quantity of the internal fundamental mixture, so that a diversity in the latter is always accompanied by a diversity in the former; but chemistry is not yet on a footing to enable us from the one to draw any conclusion respecting the other. A mineralogical arrangement founded on the external and easily perceived characters of fossils is extremely convenient for those who study mineralogy without the assistance of an experienced master and an ample collection, and who are often obliged to inquire the names of minerals with which they are unacquainted. But this arrangement is not a scientific system, in which conveniency never enters as a principle, and which requires the utmost strictness of which science will admit. When accuracy and facility can be associated together, the advantage is no doubt great; but if this cannot be effected, the former must not be sacrificed for the sake of the latter. If therefore the scientific arrangement of mineralogy does not afford the highest degree of facility in the external examination of minerals, no system merely founded on this advantage can have its claim allowed for more than to rank after the proper system, as an index ranks after a book.

Through the influence of electricity on the theory of chemistry, this last science has experienced a revolution, and received a greater and more important accession of influence, than it did through the doctrines of either Stahl or Lavoisier. The influence of the electro-chemical theory extends even to mineralogy, whose doctrines must receive an equal extension with those of the parent science, although no attempt has yet been made to apply this theory to mineralogy.

From the electro-chemical theory we have been taught to seek in every compound body for the ingredients of opposite electro-chemical properties, and we have learned from it that the combinations cohere with a force which is proportionate to the degree of opposition in the electro-chemical nature of the ingredients. Hence it follows that in every compound body there are one or more electro-positive with one or more electro-negative ingredients,* which, as the combinations consist of oxides, means the same as that every body in the combination, called by us a *basis*, must be answered by another which acts the part of an acid, even supposing that in its isolated situation it does not possess the general characters for which acids are distinguished, namely, a sour taste, and the property of changing vegetable blues to red. The body, which is in one case electro-negative when combined with a stronger electro-positive, that is, which is acid when combined with a stronger basis, may in another case be electro-positive, and be united to a stronger electro-negative body, or, which is the same thing, may be the basis to a stronger acid. Thus in the union of two acids the weaker acid serves as the basis to the stronger.

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* I must once for all inform the reader that, from the consideration I have recently bestowed on this subject, I have been led to introduce this alteration into the nomenclature of which I have already given some account, in my Essay on Nomenclature and the Electro-Chemical System. (K. Vat. Ac. Handl. 1812, I H.) By electro-positives is to be understood such as have inflammable bodies or salts for bases; and by electro-negatives, the oxygen and oxides which go to the positive pole of the galvanic battery.

Thus every combination of two or more oxides possesses the nature of a salt, i. e. has its acid. And, if we suppose this combination decomposed by the galvanic battery, the first will be collected round the positive pole, and the second round the negative. Hence in every mineral composed of oxidised bodies, whether of an earthy or saline nature, we must seek for the electro-negative and electro-positive ingredients; and after the nature and qualities of these are found, a critical application of the chemical theory will tell us what the fossil in question is.

The most usual mineral combinations between oxides generally contain three oxides, of which two are bases and one acid, and less frequently two acids and one basis, resembling the two classes of double salts in chemistry. It not unfrequently happens that there are even three or four bases for one acid; but we very seldom indeed find a chemical combination of two bases, each united with its different acid. If from these combinations we suppose a subtraction of the oxygen which they contain, then analogous combinations would take place between the inflammable radicals; and as none of them possesses a very strong affinity for oxygen, (as is the case with iron, lead, silver, antimony, arsenic, sulphur,) it happens pretty often that nature produces such combinations either of inflammable or of oxidated bases.

If with these theoretical ideas we review the productions of the mineral kingdom, what a light do they at once throw on the compounds consisting of various metals united with sulphur, or of various earths and metallic oxides: order becomes at once visible in this apparent chaos, and mineralogy assumes the character of a science. We immediately discover a numerous class of minerals, the similarity of which to salts has been already pointed out by chemists, though they were unable to make a more extensive application of these resemblances. This class consists of minerals, in which silica occupies the place of an acid, and it contains an endless variety of single, double, triple, and quadruple salts, of different degrees of neutrality, or with excess of acid or base. In the same manner we discover less general classes; thus oxide of titanium, oxide of tantalum, and several metallic oxides not hitherto considered as acids, occasionally act the part of acids; so that the whole of the extensive range of earthy minerals may be classified on the same principles as salts.

The first of these reflections, in themselves altogether natural and simple, appears to me to be the most important step which mineralogy has ever made towards its perfection as a science.

During the last five years chemistry has from another quarter received a still higher improvement, through the doctrine of chemical proportions, which in the arrangement of a mineralogical system, must, if I may be allowed so to speak, give the same mathematical certainty which it has promised to give, and has in fact already given, to chemistry. No correct thinker can hesitate to believe, that the chemical laws, which have been confirmed in our laboratories by the most numerous and varied experiments, are in like manner applicable to the great whole. It is the same nature which every where operates, and the operations are governed by the same laws, whether they are directed to a certain object by human endeavours, or, in the mass of the earth, are governed by the free course of infinitely-varied circumstances. If therefore the chemical analysis of many minerals has not hitherto justified the application of chemical proportion to mineralogy, the cause of this must not be sought for in the imperfect application of the laws, but in the imperfection of our faculties, which are frequently, notwithstanding the utmost care we can bestow, overcome by difficulties which we occasionally perceive, but which also often elude our utmost attention. In the mean time a very considerable number of analyses already exist, the results of which, in fact, coincide with the doctrine of chemical proportions, and in other respects approach so near to it that the deviations may justly be considered as owing merely to the difficulty and unavoidable errors of experiment.

I shall here endeavour in a particular manner to direct the reader's attention to the circumstances which contribute to conceal the existence of chemical proportions in mineralogy; because I consider it not impossible that, by a due observance of all these, we may, at last, be able to render every analysis, conducted with due circumspection, coincident with the chemical proportions.

1. The first of these circumstances is the want of care and attention in analysis, even occasionally perceivable in the works of our greatest masters. He who bestows a glance on the much less difficult analysis of single salts, and

the difference of the results before the doctrine of chemical proportions was established, and who has seen the necessity of adopting expedients, never before thought of, for the attainment of the utmost degree of accuracy, will surely not think it at all wonderful that the analysis of the now variously combined mineral productions should not be brought to a greater certainty of result then these were. If we compare, for example, the analyses of sulphate of barytes by the most expert chemists, or of muriate of silver, phosphate of lead, &c. we shall find that the results of these analyses differ very considerably, not only from one another but from the just proportion. The same thing must also have happened in the analyses of many minerals; and these analyses are attended with another disadvantage: we cannot be certain that they were made on minerals of the same chemical identity; hence they can never prove any thing against the propriety of the application of chemical proportions to mineralogy. The first impediment therefore consists in the difficulty of conducting a mineralogical analysis in such a manner that the result shall give the correct proportions. This defect may be the most easily of all removed.

2. Another more important impediment is the difficulty, not to say impossibility, of ever obtaining, in the productions of the mineral kingdom, any combination sure and free from foreign and accidental ingredients in its mass, except in subjects divided into fractionable parts of an imperceptible and inseparable nature. A glance into the formation of minerals will serve to clear up this better. We find them either crystallized, and in that case they have passed slowly and regularly from a liquid to a solid form; or they have separated rapidly, and formed only crystalline grains, as is the case with Carara marble and the lepidolite of Utoe; or they have fallen down without assuming a crystalline shape like precipitates from fluids. These precipitates afterwards harden and form shapless masses, frequently containing heterogeneous bodies between their plates, and often mixed with crystals, which have been either rolled by a liquid from another place, or have been formed during the precipitation itself in the liquid, and have shot in the precipitated soft mass. It is clear that in so far as respects these masses of rock formed of hardened precipitates, no analysis can give a result which coincides with the chemical proportions; except it should happen that such a

precipitate should accidentally consist of only one substance, of which examples are not wanting; but when the doctrine of chemical proportions is applied to the analysis of these minerals, it will inform us of what different mixture of combinations the shapeless mass consists.

On the other hand, we are well warranted in expecting a more satisfactory result from the analyses of distinctly formed minerals, although even the most regular and clear crystal is seldom free from foreign ingredients. Let us apply the experiments in our laboratories respecting the crystallization of solutions of salts to that which, under analogous circumstances, must take place under the surface of the earth.*

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* This example is principally founded on solutions in water, although it is equally applicable to other crystallizing mixed liquids. The opinion, that minerals have been produced by the fusing agency of a high temperature and a consequent cooling, has not yet lost all its advocates, although a single decrepitating crystal, a single petrifaction, is an incontestable proof for all who can perceive what is proved by the existence of these. It is clear, on the other hand, that we often see formed crystals which, according to what we have hitherto been taught by theory, never can, as such, have been dissolved in water; for example, sulphurets and arseniurets of metals. But here we must recollect, that in the solutions which are carried on beneath the surface of the earth, a

We see, for example, that when saltpetre shoots out of the mixed ley which is obtained by lixiviating saltpetre-earth, the crystals are regular, but of a brown colour, and contain common salt. No chemist has ever supposed that either the substance occasioning the brown colour, or the common salt which is contained in these crystals, belongs in any measure to their chemical composition; but we always consider them as ingredients foreign to the solution from which the saltpetre has shot up. It is also a known circumstance that the more slowly a solution shoots, and the larger the crystals which it forms, the liquid expelled is the more

power operates which we never can dispose of in exactly the same manner in our experiments, namely electricity, and that which in our experiments is produced in the course of a day or two at most, may in the bowels of the earth require centuries for its developement. The blended masses of the globe, burst through and penetrated on all sides by intruding water, produce innumerable multitudes of electrical circuits, which cross one another in all possible directions without impeding their separate operations, like the rays of the sun on the surface of the earth, and determine the eternal activity by which the masses of the interior of the earth slowly experience incessant changes, destruction, and new forms. Crystallizations, solutions, reductions, oxidations, take place here incessantly under forms and proportions which art, unable to dispose of its efficient powers in the same manner, will never perhaps be capable of imitating.

impure. All this must happen in the same manner in the interior of the earth, when the minerals partly shoot out of mixed solutions, and partly in consequence of the mutual action of solutions on each other. The substance of which the solution contains the most, and with which it is saturated, forms the crystal; but this crystal includes parts of the solution between its plates, is rendered impure by them, and not unfrequently thereby receives a colour which by no means properly belongs to it. This is the cause why so many minerals, which, were we to judge from their peculiar ingredients, ought to be colourless, are notwithstanding red, yellow, blue, and green, &c. which colours are derived from a slight mechanical infusion of other coloured minerals, which are occasionally so very finely divided, that they do not perceptibly diminish the transparency of the crystal. Hence also we find, in the analysis of most crystallized minerals, two, three, or more ingredients, which only amount to one per cent. and sometimes even to a fraction of one per cent.. and which we have no more reason to suppose to belong to the composition of the crystallized mineral than that the common salt and the coloured substance belong to the saltpetre. It is clear that, as the result of the analysis must be judged of according to the doctrine of chemical proportions, these foreign substances must be subtracted from it; but here again we are met by another difficulty: we cannot determine whether some of the substances considered as principal ingredients, or at least a part of them, do not belong to the foreign bodies which must be withdrawn. Something like a complete knowledge of the minerals along with which the substance investigated occurs, may also be of some assistance in enabling us to determine the proper analytical result.

3. Another circumstance which has hitherto been less observed is, that when a solution containing two or more combinations is saturated with several of them, and begins to depose crystals, it happens sometimes that a particle of one compound is deposited near to, or along with, several particles of another compound; so that united they form a crystalline figure, which in colour, shape, transparency, specific gravity, altogether deviates both from the substance which constitutes its principal mass, and from that which is mixed with the former. The smaller ingredient often does not amount to one per cent. of the whole weight, though sometimes it amounts to more. The

relative quantity of the substances associated together in the construction of such a crystal appears, so far as our experience reaches, to depend altogether on the quantities of each which the liquid at the moment of crystallization has to depose. Chemistry affords many such examples; as the crystallization of common salt in octohedrons and of sal ammoniac in cubes in urine, the simultaneous crystallization of nitrate of lead and arseniate of lead, when a solution of the latter salt in nitric acid is evaporated. We have another striking and beautiful example in sal ammoniac crystallized in a saturated solution of muriate of iron. The salt crystallizes in transparent, regular, hollow, ruby-red cubes, in which the proportion of oxide of iron often does not amount to one per cent. These crystals give nearly a colourless solution in water, from which the sal ammoniac is expelled in the usual manner by evaporation, leaving a trace of muriate of iron in the mother ley. We have another appropriate example of salts of a similar nature crystallizing together in the residual liquid which remains after the Irish process for making oxymuriate of lime. (Wilson, Annals of Philosophy, i. 365.) Here the crystal is composed of sulphate of soda, muriate of manganese, and about one half per cent. of muriate of lead; salts which cannot exist together but in such an acid solution as that from which they were expelled, and which separate whenever they are dissolved in pure water.

I am persuaded that such is the case with many crystallized minerals, although we have not hitherto had leisure to carry through the investigation. Thus, for example, it appears to be pretty certain from the analysis of Stromeyer, that the crystalline form of arragonite, so much the subject of dispute, and which deviates in so remarkable a manner from the carbonate of lime, is owing to such a formation. Particles of carbonate of strontian, with their water of crystallization, having united in a certain order with the particles of carbonate of lime, give birth to a secondary form which cannot be derived from the primitive form of pure carbonate of lime. Hence we may conceive why arragonite contains such small portions of water chemically combined, from one half to three fourths and one per cent., on the dissipation of which its transparency is destroyed; for this quantity of water depends on the quantity of carbonate of strontian, of which it constitutes the water of crystallization.

But still it is not to be dissembled that there are many difficulties in the way of every attempt to bring the analysis of minerals, and the conclusions deduced from it, to the highest possible perfection. I am emboldened, however, to hope that these difficulties will not be insurmountable.

It remains for me now to say a few words respecting the determination of the *quantitative* result of such analyses, and the correct distribution of the ingredients of the minerals. It is clear that if, in stating the composition of salt of alum, for example, we were not to go farther than to consider it as consisting of potassium, aluminum, sulphur, hydrogen, and oxygen, in a scientific point of view we should derive but little advantage from such a statement. We come a step nearer to the nature of the compound, when we consider it as composed of sulphuric acid, alumina, potash, and water. The composition of this salt was long supposed to be this by chemists; and from that circumstance it received the name of triple salt, or a salt which consisted of three principal ingredients. The next step to a more perfect knowledge of the nature of alum was the considering it as consisting of sulphate of potash and sulphate of alumina with water of crystallization, whence it received the appellation of double salt.—Lastly, the doctrine of the chemical proportions completed, if I may so speak, our knowledge of the composition of this salt, by showing that it consists of one particle of sulphate of potash, three particles of sulphate of alumina, and twenty-four particles of water of crystallization.

The chemists have long considered minerals as composed of peculiar earths, without pointing out the exact combinations of these, and without determining the definite proportions in the combinations, precisely as they did with the ingredients of alum at no very remote period. From the developement of the electro-chemical theory, and the discovery of the laws of the chemical proportions, it has become necessary to adopt a similar scientific exposition of the nature of minerals. Our predecessors, and among them the admirable Klaproth more especially, by their various analyses, afford us many materials for this attempt, although its full accomplishment can only, without doubt, be the result of future labours carried on with a due regard to the substances, and with all possible attention to obtain the utmost accuracy, without which the object never can be attained.

It is the illustration of that class among minerals in which silica is the electro-negative ingredient, and supplies the place of an acid, which throws the greatest light over the rest of mineralogy, because this class is the most numerous, and because what applies to it applies in like manner of itself, naturally and without violence, to the other classes which are not so well known. I shall give to this class the general name of *Siliciates.*

In my attempt to establish the first foundations of an electro-chemical system, with an appropriate nomenclature, (Kongl. Vet. Ac. H. I. H. 1812,)* I mentioned the combinations of silica with other oxides as salts, which I called siliciates.—It would certainly have been premature to have then endeavoured to turn more of the reader's attention to mineralogical siliciates, because the confused chaos which was spread over them might perhaps have had a tendency to prejudice the reader against these ideas, especially as the nature of the treatise would not admit of a farther exposition of the subject. I have since that period, with a truly sincere pleasure, learned that Mr. Smithson, one of the most experienced mineralogists of Europe, without any knowledge of my essay, has published a similar idea in a memoir on the nature of stilbite and mesotype. It cannot be denied that this coincidence of result, derived on the one hand from pure chemistry, and on the other from an analytical mineralogical point of view, affords a strong proof of the accuracy of the result, which induces me to hope that no mineralogist fully acquainted with the present state of chemistry will any longer entertain any doubt respecting it.

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* Also in De la Metherie's *Journal de Physique*, Oct. 1811.

Silica considered as an acid possesses the property of giving siliciates of many different degrees of saturation. The most general are those in which the silica contains the same quantity of oxygen with the base. These we shall hereafter call *siliciates*. The next most general are those in which the silica contains three times the oxygen of the base. To these we shall give the name of *trisiliciates*. It not unfrequently contains twice the oxygen of the base, and these combinations we call *bisiliciates*. Silica produces also a great number of combinations with excess of base of different degrees, *subsiliciates*, which as something may be gained through a distinction of terms, we may denote by the appellation of *bi*, *tri*, &c. for example, *bialuminous subsiliciate*, *trialuminous*, &c. all announcing that the base (in the case of silica) contains twice or three times the oxygen of the silica.

Silica, like other acids, gives also *double siliciates*, partly with and partly without water of crystallization. We most frequently find that the bases, which have a tendency to produce double salts with other acids, do the same thing here, in the same manner as in the double siliciates we again find, although with many exceptions, the same proportions between the bases, as in the other previously known double salts of the same bases. Hence, for example, if in the common felspar we could exchange silica for sulphur, the combination would be alum without water.

But nature, in her rich stores, where we find a great number of siliciates which obey without the smallest resistance the most feeble degree of affinity, exhibits also a number of combinations still more various, for which, from the experience of our laboratories, we have few or no analogous combinations to produce. Thus, for example, we find siliciates with from three to four, and perhaps (on a more extensive experience) with even more bases, which all form one common combination, and whose pure crystalline texture seems to render it evident that it must be considered as one chemical whole, unless it should be hereafter proved by circumstances that such bodies belong to the class of crystals which are formed of many different substances lying in juxta position, but not chemically combined. It often happens also in this case that these numerous siliciates are not of the same degree of saturation, but that one or more of the weaker bases are subsiliciates or siliciates, while one or more of the stronger are bi- or tri-siliciates; (such is, at least, what analyses at present afford us). That similar combinations are not produced in our laboratories arises evidently from this, that we usually obtain our result through the application of circumstances, the operation of which is much too rapid and violent to admit the influence of the weaker affinities.

I have also had occasion to ask myself the question, if it were credible that in such a slow concrete combination, siliciates of the same basis, but in a different state of saturation, could be united with siliciates of another basis in one chemical whole; for example, if a particle of siliciate of potash could be united with two particles of siliciate of alumina, and two particles of subsiliciate of alumina. Theoretical causes induce me to consider this as less probable. It is therefore more likely, when such a case happens, that the mineral is to be considered as a hardened mixture of two siliciates in a different state of saturation, like a mixed solution of a neutral and subsalt of the same base. Such, for example, is the composition of agalmatholite, according to the analysis of John. However the solution of this must be left to experience. That two unequally saturated siliciates cannot be combined without the intervention of a siliciate of another basis, which constitutes the fundamental particle or unity of the combination, follows from the doctrine of chemical proportions.

To enable the reader to determine how far these theoretical problems are just or not, we shall add some examples of not only simple but double and higher siliciates.

A. EXAMPLE OF SINGLE SILICIATES.

1. *Calcareous Trisiliciate.*—A stone from Adelfors, analysed and described by Hisinger in the Physical, Chemical, and Mineralogical Transactions, Part I. p. 188. It consists of

	Result obtained.				Calculated Result.
Silica	57·77	holding	28·75	3	58·62
Lime	35·50	oxygen	9·80	1	34·58
Alumina	1·83				
Oxide of Iron	1·00				
Loss	3·85				

The small figures to the right denote unity and the multiples of unity. The last numbers show the computed result from analysis.* Now

* It is of the utmost importance for these calculations to know the quantity of oxygen which the silica contains. By a direct experiment on a combination of silica and iron melted together, I found that the silica contains nearly 48 per cent. oxygen. Stromeyer has stated the proportion of oxygen at 55 per cent. The true proportion must lie between these, which I have calculated from John Davy's experiments with silicated fluoric acid. He found that 100 parts of fluoric acid could be combined with 159 parts silica, and that these 259 parts could farther receive 84·33 parts ammonia. From the quantity of oxygen in the ammonia, the oxygen of the silica may be calculated, because the former must be a multiple of the latter.

if we calculate the analysis of this mineral, we find that the contents of the oxygen of the lime are 9·8 which × 3 = 29·4, which differs little from 28·75, which is the computed oxygen of the silica obtained. The other ingredients of the mineral are obviously altogether foreign to its chemical constitution.

The ammonia contains 46·88 per cent. oxygen, consequently the 84·33 parts contain 39·466 oxygen. From my synthetical experiments on the composition of silica, we find that 159 parts silica must contain 76·32 oxygen, but 39.466 × 2 = 78,932, which does not materially differ; if then 159 parts silica contain 78·932 parts oxygen, that earth must contain 49·64 per cent. of oxygen, at which I have in the subsequent part of this Treatise everywhere computed it. For further particulars I refer to my Treatise on Chemical Volumes, (art. Silicium.) See *Annals of Philosophy*, ii. 443, and iii. 51, 93, 244, 353. The contents of alumina are calculated agreeably to an Essay of mine published long ago, at 46·7 per cent. of oxygen, magnesia at 38, lime at 28, barytes at 10·5, soda at 25·66, potash at 17 per cent. oxygen, &c. I must also caution the reader, especially in more compound minerals, not to expect the analysis to coincide exactly with the calculation; this would at present be too severe a demand, and I have thought it proper to content myself with such results where the difference from the calculation does not exceed the bounds of usual errors of observation in any other analysis. To facilitate the labour of the reader I have uniformly placed to the right what the results according to theory or more correct formula ought to be.

2. *Calcareous Bisiliciate*—Werner's Schaalstein, Haüy's Spath en Tables, Table-spar. Analysed by Klaproth, Beyträge, iii. 291.

Silica	50	contain oxygen	= 24·82	2 or	6	59·00
Lime	45		12·6	1	3	44·33
Water	5		4·4	⅓	1	4·70

The silica is here combined with 1½ as much lime as in the foregoing mineral, and contains therefore twice the oxygen of the base, while the water of crystallization contains ⅓ of the oxygen of the base.

3. *Aluminous Siliciate*—Nephelin, Sommite of Karsten. Analysed by Vauquelin, Bullet. de la Soc. Phil. An. V. p. 12.

Silica	46	contain oxygen	= 22·83	1	46·05
Alumina	49		23·03	1	48·95
Lime	2				
Oxide of Iron	1				

4. *Zinc Siliciate*—Calamine. Analysed by Smithson, Philosoph. Transac. 1803. Consists of

Silica	25·0	contain oxygen	= 12.41	1	26.79
Oxide of Zinc	68·3		13·40	1	66.51
Water, Loss	6·7				

5. *Copper Siliciate*—Dioptase. There is no analysis of this mineral that can be depended on. It is the only siliciate of copper with which we are acquainted.

6. *Manganese Bisiliciate*—Red Manganese-flint. See my analysis of it in Afh. i Fys. Kem. och Mineral. i. 110. It contains

Silica	40·0	contain oxygen	= 19·86	2	42·26
Protoxide of Manganese	47·7		10·50	1	45·44
Oxide of Iron	4·6				
Lime	1·5				

In this analysis I obtained an augmentation of weight instead of a loss, because the quantity of manganese was determined by weighing the peroxide extracted by the analysis, while the mineral contained it in the state of a protoxide. In the original paper therefore there is 53 per cent. peroxide, which answers to 47·7 per cent. protoxide.

In this description of the analysis of this mineral I have made mention of a crystallized combination of oxide of manganese with silica, persiliciate of manganese, which I accidentally obtained with it. Hence it is probable that such a mineral may hereafter be discovered.

7. *Manganese Siliciate*—Manganese flint from Klapperud. Analysed by Klaproth, Beytr. iv. 138.

Peroxide of Manganese	60	reduced to the corresponding quantity of protoxide, contains of oxygen	= 12·0	1
Silica	25	contain oxygen	= 12·4	1
Water	13		12·4	1

As Klaproth found that this mineral, notwithstanding its dark colour, dissolved easily in nitric acid, it is clear that it contained protoxide, and that all its ingredients contained the same quantity of oxygen.

8. *Trisiliciate of Iron*—Mineral from Tunaberg. Analysed and described by L. Hedenberg, Afh. i Fys. Kem. och Mineral. ii. 169. It contains

Silica	40·62	contain oxygen	= 20·15	3	42·64
Protoxide of Iron *	32·53		7·11	1	30·56
Water	16.05		14·12	2	16·00
Carbonate of Lime	4·93				
Oxide of Manganese	0·75				
Alumina	0.37				

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* The original has 35·25 per cent. determined from the oxide heated with oil, which corresponds to 32·53 per cent. protoxide.

9. *Siliciate of Cerium*—Cerite. From a mean of the analysis of Hisinger, Afh. i Fys. Kem. och Mineral. iii. It contains

Silica	18	contains oxygen	=	8·90	1	18·6
Oxide of Cerium	68	reduced to protoxide, contains of oxygen	=	9·2	1	68·0

As the mineral is dissolved in muriatic acid without the evolution of oxymuriatic acid, and the oxide in the state in which it is obtained by the analysis gives out oxymuriatic acid when treated with muriatic acid, it is clear that the mineral must contain protoxide. It derives its colour chiefly from the oxide of iron which enters into it to the amount of 2 per cent.

Silica gives similar siliciates with most bases. I am convinced that mineralogy will hereafter exhibit not only siliciates of magnesia, but probably, likewise, siliciates of potash, soda, barytes, &c.

B. EXAMPLE OF DOUBLE SILICIATES.

1. *Trisilicias Kalico-calcicus, Trisiliciate of Potash and Lime*—Icthyophtalmite Apophyllite. Analysis by Rose, Neue's Allg. Journal du Chemie, v. 44. It contains

Silica	52·0	contain oxygen	= 25·81	18	50·83
Lime	24·5		6·72	5	25·04
Potash	8·0		1·36	1	8·24
Water	15·0		13·23	10	15·89

This mineral is thus a double salt of lime and potash, in which the former contains five times the oxygen of the latter, and the silica three times the oxygen of the bases. It is a salt composed of one particle of trisiliciate of potash and five particles of trisiliciate of lime. The proportion of silica in this analysis may turn out 1 per cent. too high from a mixture of quartz in the specimen examined.

2. *Bisilicias Magnesico-calcicus, Bisiliciate of Magnesia and Lime*—Malacolite from Langbanshyttan. Analysed by Hisinger, Afh. i Fys. Kem. och Mineral. iii. 300.

Silica	54·18	contain oxygen	= 26·79	4	53.5
Lime	22·72		6·4	1	23.7
Magnesia	17·81		6·7	1	17·5
Oxide of Iron	2·18				
Oxide of Manganese	1·45				
Volatile matters	1·20				

It consists, therefore, of one particle of bisiliciate of lime united with one particle of bisiliciate of magnesia.

3. *Silicias Magnesico-calcicus, Siliciate of Magnesia and Lime*—Serpentine from Bajmas. Analysed by Hisinger, Afh. i Fys. Kem. och Mineral. 303.

Silica	32·00	contain oxygen	= 15·78	6	33·86
Magnesia	37·24		14·14	5	36·86
Lime	10·20		2·85	1	10·71
Water	14·00		12·35	4	12.71
Clay	0· 5				
Oxide of Iron	0· 6				

Hence this combination is a double siliciate with water of crystallization, consisting of one particle siliciate of lime, five particles siliciate of magnesia, and four particles of water. The original analysis has 10·6 particles lime: but as 100 parts of the mineral produced 24·4 parts gypsum, the proportion of lime, according to a more accurate computation, is only 10·2 per cent.

C. EXAMPLE OF A COMPLEX SILICIATE.

Byssolite—Analysed by Vauquelin, Haüy's Traité de Mineralogie, iv. 334. It consists of

Silica	47·0	contain oxygen	= 23·56	8	48·00
Magnesia	7·3		2·77	1	7·86
Lime	11·3		3·16	1	10·70
Oxide of Iron	20·0		6·1	2	19·36
Manganese Oxide	10·0		3·0	1	9·68

The difficulty of separating lime and magnesia with precision may have occasioned a loss in the former and an increase in the contents of the latter. If we suppose them to contain an equal quantity of oxygen, and divide the silica equally among all the four bases, then the salt will consist of one particle bisiliciate of lime, one particle bisiliciate of magnesia, one particle bisiliciate of manganese, with two particles of siliciate of iron.

I shall, however, in the following instances adduce many examples of similar complex minerals, from the analysis of which we are not to expect all the precision which is requisite in putting the doctrine of chemical proportions to the test of experiment.

It is evident that when we apply the doctrines of chemistry to mineralogy, and the productions of the latter are classified according to the theory of the former respecting their composition, the nomenclature of chemistry must also to a certain extent be applied to mineralogy, and it must naturally considerably facilitate its study if we can retain the chemical name: but unfortunately the chemical nomenclature cannot advantageously be applied further than to simple salts, or simple sulphurets, arseniurets, tellurets, &c. When these are doubled or variously multiplied, a chemical name, deduced from the composition, would be long, harsh, and of difficult utterance; and the most universal zeal for the introduction of a strictly scientific nomenclature could not prevent it from being supplanted by a shorter unscientific name. Chemists always say alum instead of sulphate of potash and alumina, which may very properly be used as a definition but not well as a name. It is therefore clear that the chemical nomenclature is not sufficient for mineralogy, and that for complex substances we must avail ourselves of shorter empirical names. Let chemical names be retained as long as they can be used, but when that is no longer the case, I consider the oldest and most generally received names the best; and I see no cause to alter such a name except it be (*a*) ambiguous, (as for example muriacite for gypsum which does not contain water,) or (*b*) derived from a language which has no relation to the Latin, and such as cannot be Latinised, for example, *Kreutzstein;* because every scientific nomenclature must have a relation to a Latin fundamental nomenclature, from which every language ought not to translate the new name, but merely to ingraft it by inflexion into their own. It is only in this manner that perspicuity can be obtained. I cannot, therefore, but highly disapprove of the wanton desire shown by many mineralogists to metamorphose the name of well known minerals, by which the study of them is rendered considerably more difficult, and the synonomy comes to be the most difficult part of the whole science. What has mineralogy gained by the exchange, when it received *apophyllite* for *icthyophtalmite,* as the property of this mineral, which gave occasion to the former name, is common to many other minerals as well as it; for example, to many species of mica? Perhaps this strong desire of metamorphosis is no other than the desire of authors to give something of their own to science; but such a present, should it go no farther, it is equally in the power of all to make, and it seldom excites in the reader that gratitude on which the author perhaps calculated.

But before I come to the exposition of the manner in which I conceive a system of mineralogy ought to be arranged, I must name some words necessary for the purposes of mineral analysis, in such a manner that the reader may at once recognize the nature and quantity of the constituent to which the mineral is indebted for its chemical nature. That this cannot be effected by the numerical arrangement, even when assisted as in the examples which I have just now adduced, the reader must have already perceived. The result of mineralogical analysis must therefore be arranged in two manners, a mechanical result, the numerical, and a scientific result, which in the preceding Essay I was obliged to express by a short explanation subjoined to every analysis. This explanation may, by the substitution of peculiar signs, become superfluous; and by a short and easily comprehended formula, the reader may in a moment understand the scientific result.

In my Essay on Chemical volumes I have proposed similar signs for the arrangement of chemical combinations agreeably to the views of the doctrine of proportions. These signs require a full acquaintance with the composition of the substance which they represent, and they include all the ingredients of the elements, with the number of their volumes in a compound body; but these formulæ, precisely from the circumstance of their expressing so much, are too long and difficult to be comprehended in a moment. I shall call these *chemical formulæ*, and in this Essay I shall use them only for inflammable minerals and single salts.* The earthy minerals require easier formulæ, which merely express what the mineral is, and I shall propose some of this description under the name of *mineralogical*, and shall for this purpose follow the rules given by Thomson in his System of Chemistry. He arranges the initial letters of the name of the earths in such order, that he begins with that of which each fossil contains the most, and so on in succession till that of which it contains the least. I cannot make use of the same letters as Thomson, because they are merely relative to the English name; and as these formulæ ought everywhere to be equally understood, I consider they ought to be founded on the Latin nomenclature. In order that no confusion may arise from the two kinds of formulæ, I shall write the mineralogical in Italics. Let us then take Silica = *S*, Alumina = *A*, Zirconia = *Z*, Glucina = *G*, Yttria = *Y*, Magnesia = *M*, Lime (calx) = *C*, Strontian = *St.*, Barytes = *B*, Soda (natron) = *N*, Potash (kali) = *K*, Peroxide of Iron = *F*, Ferrose Protoxide of Iron = *f*, the two united *Ff*, Oxide of Zinc = *Zi*, Peroxide of Manganese = *Mg*, and Protoxide of Manganese = *mg*, Water = *Aq*.

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* See farther, on this subject, the Appendix on Chemical signs.

When in the formula the symbol of the earth appears without a number before or after it, it signifies that in that case the quantity of oxygen of the earth is the unity in the formula. A cipher to the left of the letter signifies a like number of such unities; and a small cipher above to the right, denotes that the earth contains so many times as the cipher expresses the oxygen of the earth standing beside it. We shall take some examples from the analyses we have already gone through.

The composition of nephelin, in which alumina and silica contain equal oxygen, is expressed by $A\,S$.

Table-spar, in which the silica contains twice the oxygen of the earth, is expressed by $C\,S^2$.

The formulæ of more various composed fossils are composed from the formulæ of the single salts which enter into them, for example, the composition of icthyophtalm $= K\,S^3 + 5\,C\,S^3$, of byssolite $= M\,S^2 + C\,S^2 + Mg\,S^2 + 2\,F\,S$.

The mineral productions divide themselves at first sight into two classes:

1. *Bodies formed entirely agreeable to the principles of composition in unorganic nature*, that is, the union of *binary* bodies and *binary* bodies with each other. (I have already in another place shown that the principle of unorganical compositions is that it consists only of two elements, and when they seem to have a more various composition, it proceeds from their containing a combination of two or more such bodies composed of two elements.)

2. *Bodies formed agreeably to the principle*

of composition in organic nature, and therefore considered as remains of a former organization. (I have also in the same place shown that the principle in organic compositions consists in the circumstance that more than two bodies, usually three or four, of which oxygen is always one, are combined into one which cannot be considered as a composition of two *binary* ingredients. So that unorganic nature consists of *binary* bodies and their combinations, and organic nature consists of *ternary* and *quaternary* bodies; partly separate, partly united with each other, and partly with binary, that is, unorganic bodies.)

In most systems of mineralogy, diamond, graphite, coal, asphalt, and naphta, have been arranged in the same class. It is evident that this classification is as inaccurate as if we were to describe asphalt or naphta in the chapter of carbon. For the same reason it is clear that honeystone cannot belong to the former class, but must be treated of in the latter.

A correct arrangement of the former of these classes forms the principal object of a mineral system. As mineralogy constitutes a part of chemistry, it is clear that this arrangement must derive its principle from chemistry. The most perfect mode of arrangement would certainly be to allow bodies to follow each other according to the order of their electro-chemical properties, from the most electro-negative, oxygen, to the most electro-positive, potassium; and to place every compound body according to its most electro-positive ingredient. But this arrangement has difficulties which at present render it almost impossible, and of which the principal is that we only know in a very incomplete manner the electro-chemical relations of single bodies. We must therefore, until we become better acquainted with this subject, content ourselves with an approximate arrangement. We divide the single bodies into three classes, *oxygen*, *simple inflammable bodies* which have not the properties of metals, which I have denoted by the name of *metalloids*, and *metals;* and we distribute them in the order in which they follow one another, from the most electro-negative to the most electro-positive, in every class. This order is nearly as follows:

1. *Oxygen.*

2. *Metalloids.*

Sulphur
Nitricum
Muriatic radicle
Phosphorus
Fluoric radicle
Boron
Carbon
Hydrogen

3. *Metals.*

Arsenic
Chromium
Molybdenum
Tungsten
Antimony
Tellurium
Silicium
Tantalum
Titanium
Zirconium
Osmium
Bismuth*
Iridium
Platinum
Gold
Rhodium
Palladium
Mercury
Silver
Lead
Tin
Nickel
Copper
Uranium
Zinc
Iron
Manganese
Cerium
Yttrium
Glucinum
Aluminium
Magnesium
Calcium
Strontium
Barytium
Sodium
Potassium

Every one of these single bodies can constitute

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* I have placed bismuth here, not because I am of opinion that this is its most proper place, but because I do not know where it possibly can have its place, and yet somewhere it must, or some way or other, be placed.

a mineralogical family, which will then consist of that single body and all its combinations with bodies which are electro-negative towards it, that is, which with some few exceptions precede it in the above series.

The family is divided into orders according to the different electro-negative bodies with which the most electro-positive are combined: these orders may then be, for example, 1. Sulphurets, 2. Carburets, 3. Arseniurets, 4. Tellurets, 5. Oxides, 6. Sulphates, 7. Muriates, 8. Carbonates, 9. Arseniates, 10. Siliciates, and so on. It is clear that the number of the orders is increased in proportion as we approach the positive end of the series. In this manner we constitute orders to families and families to orders, that is, determine families according to the electro-negative ingredients, and orders according to the electro-positive. Both may have their advantages and their difficulties, like all other systematic arrangements; and their various advantages cannot be fully ascertained except by a complete application of both. So far as I can perceive, the former has considerable theoretical advantages, notwithstanding the latter possesses different practical good qualities if I may so speak; thus, for example, it arranges the whole of the extensive class of siliciates together, and thus in an uninterrupted chain shows their coincidences, differences, and transitions into one another.

When the orders are very numerous we must contrive resting points for reflection and recollection, through the use of which the whole may be easier mastered; and these must differ according to the different varieties of minerals which belong to the order. When the order does not contain more than three, four, or six different minerals, it is sufficient to divide it merely into *species*. By minerals of the same species I here mean the same thing as Werner, *the same composition and in the same proportion*. The different forms under which the same species appears are *varieties*. When again the order is very extensive, containing from 20 to 100 species and upwards, as is the case with the order of *siliciates* on electro positive bases, the memory is very much assisted by dividing it first into *subdivisions;* for example, 1st Subdivision, Salts of two ingredients, or single salts. 2d Subd. Salts with three ingredients, double salts. And

4th, Salts with three and four bases, triple and quadruple salts.

These subdivisions may be divided next into *genera*, and the genera into *species*. A genus comprehends all the minerals which have nearly the same ingredients. The species again consists of the variations in the relative quantities of these ingredients.

This is certainly not the fit place to go farther into the particulars of the mineralogical arrangement, particularly as these are no other than expedients for the sake of convenience, which appear to most advantage in an arrangement of the whole system, and may well be dispensed with in the exposition of single parts. However I shall, in the order of siliciates of the family of alumina, give an arrangement into subdivisions, genera, and species, in the way that I think ought to be adopted. That I do not adopt it in other places is because I have brought forward so few species that this does not become necessary.

With respect to the determination of the family to which the minerals belong, we must observe a somewhat different principle for the inflammable and for the oxidated orders: thus, for example, when the question is whether a sulphuret, or arseniuret, &c. be double or complex, *it is placed under that one of the electro-positive ingredients of which it contains the greatest number of particles, or if the number of these is equal, under the most electro-positive.*

When again the question respects an oxidated mineral which consists of two or more oxides, *it is then always placed under the most electro-positive of the oxides without reference to the number of the particles.* Through the adoption of these two circumstances we obtain this great advantage, that minerals of kindred compositions are placed near one another, and that, for example, the whole of the great class of double, triple, and quadruple siliciates are as good as arranged together under the three or four last electro-positive bodies which end the system.

I shall here give some examples of the arrangement, and for that purpose shall make choice of three families, silver, iron, and aluminium. I shall, however, not follow the principles too strictly, because my principal object was to show on the one hand the possibility of the scientific arrangement, and on the other the correctness of the application of the chemical proportions. I have therefore in every one of the three families chosen different species, which, had I been writing an entire system, I should have placed in another family. But in the arrangement which in the following part of this treatise I have adopted, my view has principally been to create a scientific arrangement; so that these examples may be considered more as imperfect monographs of each family, than as parts extracted from a whole system connectedly digested.

SILVER FAMILY.

1*st Order*. Pure Silver.

Argentum nativum, native silver, with all its varieties.

2*d Order*. Sulphurets.

1st Species. *Bisulphuretum Argenti*—Sulphuret of silver. The chemical formula for this composition is $Ag + 2\ S$.

2d Species. *Sulphuretum Argenti, Stibii, et*

Ferri—Sprödglanzerz. Analysed by Klaproth, Beytr. i. 166.

Silver	66·5	receives of sulphur	= 9·83	3
Antimony	10·0		3·67	1
Iron	5·0		3·00	1
			16·50	
Copper, Arsenic, Stony matter	1·5			
Loss	5·0			

If the loss in this experiment is supposed to be chiefly sulphur, the analysis then gives 17 per cent. sulphur, while the metals receive 16.^{5}. Klaproth determined the proportion of the antimony at from 10 to 13 parts, by means of oxide of antimony obtained from aqua regia, and dried but not heated to redness, which 13 parts contain, besides oxygen, both water and muriatic acid, according to my experiments on oxides of antimony, and could not therefore have contained more than about nine parts metallic antimony. This mineral appears to be rather a mechanical mixture than a chemical combination of sulphurets of silver, antimony, and iron.

3d Species. *Sulphuretum Argenti, Ferri, Cupri,* *et Stibii—Grau giltigerz.* Analysed by Klaproth, Beyträge, iv. 72.

Silver....	13·25 to	10·25	Receives oxygen in proportional degrees of oxygenation, according to an average	=0·98	1	1	Receives sulphur	= 2·	14·25
Iron	7·00	7·00		2·06		2		8·4	7·25
Copper ..	25·50	27·00		6·37		6		6·4	25·65
Antimony	27·00	23· 5		3·16		3		9·4	25·65
Sulphur and Loss.	27·25	30· 5						26·2	27·20
		1·75							

Before I enter on the exposition of this analysis I shall state what I understand by proportional degrees of oxygenation. In the calculation of the number of volumes (atoms, particles) in which the metals are contained in similar combinations, there is no easier way of arriving at the result, without long calculation, than by determining how much oxygen the metals take up in the oxides, which are assumed to contain the same number of volumes of oxygen. In the above analysis all the oxygen is calculated on the supposition that the oxides contain two volumes of oxygen. Chemistry however has not yet discovered this degree of oxidation in antimony; although it is possible that it may exist; but at all events it is a convenience for us to avail ourselves of it in calculation. To those who may be disposed to consider this as a sort of pleading for a feeble degree of the honour of proportion, I must be allowed to say that such a merely calculated oxide never appears where the higher or lower existing degrees of oxidation can be obtained, of which the contents of oxygen constitute a multiple with a whole number of unities in the combination, and that it is therefore merely for convenience' sake that I avail myself of the imaginary oxide.

From the small variations in the analyses of the same mineral we easily perceive that, in case it is a chemical combination and not an aggregate, it contains one particle (atom or volume) of silver, two particles of iron, three particles of antimony, and six particles of copper, combined with sulphur in such proportions that the copper gives a sulphuret, the silver a bisulphuret, the antimony a trisulphuret, and the iron a quadrisulphuret; altogether the most usual sulphurets in which these metals appear. The formula which expresses this composition is $Ag\,S^2 + 2\,Fe\,S^4 + 3\,Sb\,S^3 + 6\,Cu\,S$.

4th Species. *Sulphuretum Argenti et Stibii cum Oxido Stibioso*—Red silver ore. Analysed by Klaproth, Beytr.

1

Silver..............	62·0	takes up oxygen in proportional degrees of oxygenation.	— 4·588 2
Antimony..........	18·5		2·298 2
Sulphur............	11·0		
Sulphuric acid......	8·5		

No chemical principle leads us to suppose that sulphuric acid is found in this mineral. Klaproth was not of opinion that the oxygen in the mineral belonged to the sulphur. Proust afterwards discovered that the sulphuret of antimony possesses the property which no other sulphuret does, of combining chemically with oxide of antimony; and that crocus of antimony is the result of the combination, which by fusion can be mixed in almost every proportion both with the protoxide and with the sulphuret of antimony, and with other metals less inflammable than antimony. The colour of the mineral shows that it contains a combination resembling crocus of antimony. If this combination, as I once from a hasty experiment on crystalline crocus of antimony was led to suppose, is composed of two particles of sulphuret of antimony with one particle of oxide of antimony $= 2\,Sb\,S^3 + Sb\,O^3$, then $\frac{2}{3}$ of the contents of antimony in the mineral are combined with sulphur, and $\frac{1}{3}$ with oxygen. But 62 parts silver take up 9·176 parts sulphur, and 12·334 parts antimony ($\frac{2}{3}$ of

18·5) take precisely the half of it = 4·588 parts sulphur. Hence the composition of this mineral is expressed by $Sb\,O^3 + 2\,Sb\,S^2 + 6\,Ag\,S^2$. Consequently the composition of the mineral in numbers is

Silver	62.00	Sulphuret of silver	71·176	6
Antimony	18.60	Sulphuret of antim.	16.922	2
Sulphur	13.76	Protoxide of antim.	7.217	1
Oxygen	1.15			

which, as far as the proportion of sulphur is concerned, coincides with the result of Klaproth.

3d *Order.* Stibiets.

It is known that antimony forms two oxides that have acid properties, whence it follows that, like arsenic, tellurium, and sulphur, it must appear as an electronegative ingredient in respect to other metals, which is also the case with both silver and lead. Hereafter still more stibiets may be discovered.

1st Species. *Stibietum Biargenti*—Antimonious silver ore. Analysed by Klaproth, Beytr. iii. 175.

Silver	.77	takes oxygen in proportional degrees of oxidation	= 5·798	2	77
Antimony	.23		2·850	1	23

Hence the analysis gives this stibiet exactly $Sb + 2\,Ag$.

2d Species. *Stibietum Triargenti*—Silberspiesglans. Analysis by Klaproth, Beytr. ii. 301.

Silver......84	takes oxygen in prop.	=	6·9	3	82·3
Antimony..16	degr. of oxidation		2·0	1	17·6

Hence the analysis deviates very inconsiderably at farthest from three particles silver to one particle of antimony, and probably would not exhibit the smallest difference if the silver in the analysis had not been weighed after copper, which always occasions it to be somewhat coppery. The formula for the composition of this stibiet is $Sb + 3\,Ag$.

4th Order. Tellurets.

1st Species. *Bitelluretum Argenti* with *Setelluretum Auri*—Aurum graphicum. Analysis by Klaproth, Beytr. iii. 20.

Tellurium....60	take oxygen in proportional degrees of oxidation	=	14·80	20	61·38
Gold 30			2·40	3	28·39
Silver 10			0·74	1	10·23

The proportion of gold in this analysis appears nearly two per cent. too high. This mineral, supposing the analysis in other respects correct, is = $Ag\ T^2 + 3\ Au\ T^6$. The disposition of the gold to take six volumes of tellurium is analogous to what happens in the common telluret, as well as sulphuret and oxide, in all of which it unites with three volumes of the electro-negative body.

2d Species. *Bitelluretum Argenti* with *Bitelluretum Plumbi* and *Tritelluretum Auri*—Weisserz, Gelberz. Analysed by Klaproth, Beytr. iii. 25.

Telluret	44·75	takes oxygen	=	11·34	15	44·05
Gold	26·75	in proporti-		2·14	3	27·20
Lead	19·50	onal degrees		1·56	2	18·95
Silver	8·50	of oxidation		0·63	1	9·80

A trace of Sulphur.

In looking over these figures we find that the contents of the silver are nearly one per cent. too small. But when we see that in the analysis of Klaproth $\frac{2}{3}$ of the contents of silver are obtained by fusion with carbonate of potash from a mass of quartz grains, which amounted to 12 times the weight of the silver, we are not to wonder that the whole quantity of silver found was not so fully brought out as to give the utmost accuracy to the proportion of silver in the result. Allowing a small error in the proportion of silver found, this mineral will contain one particle silver, two particles lead, three particles gold, and 15 parcles tellurium; and the mineral is, agreeably to what I demonstrated in an Essay published long ago, (K. V. Ac. Handl. 1813 sedn. Halften.*) so composed that, if the metals are oxygenated to their proper point, we obtain neutral tellurates. The formula for the composition of the mineral is therefore $Ag\,T^2 + 2\,Pb\,T^2 + 3\,Au\,T^3$.

5th Order. Aurets.

1st Species. *Biauretum Argenti*—Electrum. Analysis by Klaproth, Beytr. iv. 3.

Gold	.64	takes in proportional degrees of oxidation	5·12	2	64·88
Silver........	.36		2·66	1	35·12

Hence this mineral is $= Ag + 2\,Au$.

2d Species. *Auretum Biargenti*—Auriferous silver. Analysed by Fordyce, Phil. Trans. 1776, p. 523.

Silver.........	.72	takes oxygen in prop. degrees of oxidation	2·32	2	74
Gold	.28		2·24	1	26

The proportion of silver in this analysis is a little too low; but as it was made at a period when chemistry did not possess all its present expedients for obtaining precision, this circumstance is not to be wondered at.

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* Also in Schweigger's Journal, November, 1812.

6th Order. Hydrargyrets.

1st Species. *Bihydrargyretum Argenti*—Native Amalgam. Analysed by Klaproth, Beytr. i. 183.

Mercury	64	takes in proportional	5·12	2	65·32
Silver	36	degrees of oxidation	2·66	1	34·68

The formula for this compound therefore is $Ag + 2\,Hg$.

7th Order. Carbonates.

1st Species. *Carbonas Argenticus (Stibio-carbonas Argenticus ?)*—Carbonate of silver. Analysed by Selb, Aikin's Dictionary, Part ii. 295.

Silver	72·5
Carbonic acid	12·0
Oxide of Antimony	15·5

From the circumstance that the silver here is stated in the metallic form, and yet, that there is no loss in the analysis, it is probable that no great reliance can be placed in the result. The carbonic acid, as stated in the table, includes probably also the oxygen of the silver. On this supposition the result of the analysis is such phuret of lead and sulphuret of silver, contains the metals in such proportion that the composition is expressed by the formula, $= Pb\,S + 2\,Cu\,S + 2\,Fe\,S^2$.

3d *Order.* Carburets.

1st Species. *Supercarburetum Ferri—Graphite* —Black Lead.

The small proportion of iron in this substance long induced me to suppose it to be pure carbon, mechanically blended with a little of the carburet of iron. But as the proportion of carbon in the artificial black-lead, which crystallizes during the fusion of cast iron, exceeds 90 per cent. this body must therefore be a chemical combination; because we cannot suppose that an elementary body can separate itself from all combination with another from the mere disposition to crystallization. Besides, it is known that the crystallizing hydrargyret of potassium does not contain full three per cent. of potassium, though it is beyond all doubt a chemical combination. This demonstrates that the maximum of particles (atoms, volumes) of a body which can be combined with a single particle of another must be very great. For if, according to the analysis of Saussure, the pure native graphite of Cornwall contains 96 parts carbon for four parts of iron, and if the artificial, according to Berthollet, contains 91 parts carbon for nine parts iron, one particle of iron in the first instance is combined with 208, and in the second with 98 particles of carbon; or, allowing for a trifling error in the analyses, the former may be $Fe + 200\ C$, and the latter $Fe + 100\ C$.

2d Species. *Subcarburetum Ferri*—Native Steel from Labouiche in France. Analysed by Godon de St. Memin. Journal de Th. lx. 340.

Iron	94·5
Carbon	4·5
Phosphorus	1·0

This iron is stated to be malleable. In my analytical experiments on cast iron I found that iron which contains $3\frac{1}{3}$ per cent. carbon $= 3\ Fe + C$ is already in the highest degree brittle and completely immalleable. However if we assume this analysis to be something like correct, the combination would be $2\ Fe + C$ mixed with a little phosphuret of iron.

4th Order. Arseniets.

1st Species. *Arsenietum Ferri*—Misspickel. I know no analysis of this fossil, but believe that it may be securely calculated at

Iron	45·46
Arsenic	54·54

That is, = $Fe + As$.

2d Species. *Arsenietum Ferri*, with *Sulphuretum Cupri*—Fahlore, from the mine of Hohenbirke, at Freyberg. Analysed by Klaproth, Beytr. iv. 40.

Iron	22·5	19·52	1
Arsenic	24·1	23·68	1
Copper	41·0	45·44	2
Sulphur	10·0	11·36	2
Loss	2·0		

If therefore this mineral is a chemical combination, and the difference between the result obtained and the result calculated is to be considered rather as the fault of observation than as originating from a mechanical mixture of the ingredients of different minerals, it will be composed of $Fe\ As + 2\ Cu\ S$.

3d Species. *Arsenietum biferri* with *sulphuretum cupri*—Fahlore, another species from the mine Jonas, at Freyberg. Analysis by Klaproth, Beytr. iv. 53.

Iron	27·5	takes oxygen in proportional degrees of oxidation.	= 7·90	2		25·21
Arsenic....	15·6		3·74	1		15·29
Copper ...	42·5		10·62	3	takes 10·63 sulphur...	44·01
Sulphur ...	10·0					10·40
Antimony	1·5					
Silver.....	0·9					
Loss......	2·					

So that the arsenic is the unit in this combination, and the mineral consists of = $Fe\,{}^2As$ + $3\,Cu\,S$.

5th Order. Tellurets.

1st Species. *Supertelluretum Ferri*—Native tellurium. Analysed by Klaproth, Beytr. iii. 8.

Tellurium	91·55	takes oxygen in propor. deg. of oxid.	= 22·69	10	92·09
Iron.....	7·20		2·18	1	7·91
Gold.....	0·25				
Loss.....	1·00				

This mineral is therefore $Fe + 10\,Te$. But the number of particles of the tellurium ought to be determined with greater precision, because very small variations in the result of the analysis easily change them from 9 to 12, and this mineral probably contains some one of these numbers.

6th Order. Oxides.

1st Species. *Oxidum ferricum*—Iron glance, of various forms. Its composition is $F + 3\,O$.

2d Species. *Oxidum ferroso-ferricum*—Magnetic iron-stone, of all forms.

According to my experiments, magnetic iron-stones, and minerals merely attracted by the magnet, have the same composition,* and consist of

Oxidum ferricum	69·02	contain	= 21·189	3
Oxidum ferrosum	30·98	oxygen	7·063	1

So that the peroxide holds three times the oxygen of the protoxide. The combination is therefore = $Fe\,O^2 + 2\,Fe\,O^3$.

It is extremely probable that the pure or free black oxide of iron occurs as seldom in a mineral state as other stronger saline bases.

7th Order. Sulphates.

1st Species. *Sulphas ferrosus*—Native iron-vitriol. $Fe\,O^2 + 2\,S\,O^3$.

2d Species. *Subsulphas biferricus*—Ochre from vitriolic water, deposited from the preceding species. $2\,Fe\,O^3 + S\,O^3 + 6\,H^2\,O$.

3d Species. *Subsulphas quadriferricus*—Iron pitch ore. Eisenpecherz. *Fer oxidé resinite* Analysed by Klaproth, Beytr. v. 221.

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* See farther, Appendix IV.

Oxide of Iron.....	67	contain oxygen	= 20·56	4	67·80
Sulphuric Acid.....	8		4·80	1	8·66
Water	25		22·06	4	23·54

This analysis demonstrates to us the existence of a sulphate of iron formerly unknown. The proportion of sulphuric acid is here a slight degree too little, and that of the water, probably from mechanically adhering humidity, a little too high. It will at all events be admitted that the salt is $4\,Fe\,O^3 + S\,O^3 + 12\,H^2\,O$.

8th Order. Phosphates.

1st Species. *Phosphas ferrosus*—Native Prussian blue. $Fe\,O^2 + 2\,P\,O^5$.

This salt is usually at first *phosphas ferrosus*, but it takes in the course of time, through the agency of the air, a higher degree of oxidation, and receives a blue colour, under which it is changed to *phosphas ferroso-ferricus*. Through this change it receives a small mixture of *subphosphas ferricus*, and suffers by that means a small change in the contents of its water of crystallization.

2d Species. *Subphosphas ferricus*—Phosphated iron. *Fer phosphaté.* Lucas, Tabl. Meth. ii. 413. Analysed by Laugier, Ann. du Mus. d'Hist. Nat. iii. 405.

Oxide of Iron	41·25	contain oxygen	= 12·37	41·64
Phosphoric Acid *	22·25		12·12	23·26
Water	31·25		27·28	29·10
Silica	1·25			
Alumina	5·00			

Hence this mineral is $Fe\ O^3 + 1\frac{1}{2}\ P\ O^2 + 6\ H^2\ O$.

3d Species. *Subphosphas ferrico-manganicus—Manganese phosphaté ferrifere.* Analysed by Vauquelin, Journal de Min. No. 64, 299.

Oxide of Iron	31
Oxide of Manganese	42
Phosphoric Acid	27

This analysis does not correspond with any calculation. All that we can infer from it is that the mineral is a double subphosphate.

9th *Order*. Carbonates.

1st Species. *Carbonas ferrosus*—Sparry or

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[*] The original has 19·25 from an inaccurate calculation of the composition of the phosphate of lead.

white iron-ore. Analysed by Buchholz, Journal de Chemie und Physik.

Protoxide of Iron	59·5	contain oxygen	= 13·56	1	58·77
Carbonic Acid	36·0		26·22	2	36·73
Lime	2·5				
Water	2·0				

This mineral, which most frequently appears mixed with greater quantities than in the present example of magnesia, lime, or carbonate of manganese, is obviously a carbonate of iron composed of $= Fe\,O^2 + 2\,C\,O^2$.

2d Species. *Subcarbonas ferroso-ferricus.* It does not constitute a separate mineral, but it appears not unfrequently mechanically blended with ochres, bog ores, &c. where, through the agency of water and air, it is destroyed and transformed to hydrate of iron.

10*th Order*. Arseniates.

1st Species. *Subarsenias biferricus*—Cube-ore. *Fer arseniaté.* Analysed by Vauquelin, Brogniart, ii. 183.

Oxide of Iron	48	contain oxygen	= 14·5	2	47·59
Arsenic Acid	18		7·5	1	17·46
Water	32		28·3	4	32·95
Carbonate of Lime	2				

The salt is therefore $4\,Fe\,O^3 + As\,O^6 + 24\,H^2\,O$.

11*th Order.* Chromates.

1st Species. *Subchromis aluminico-ferricus*—Chromate of Iron. *Fer chromaté.* Analysed by Laugier, Ann. du Mus. d'Hist. Nat. iv. 325.

Oxide of Iron	34	contain oxygen	= 10·2	2	34·09
Alumina	11		5·17	1	11·17
Green Oxide of Chromium	53		15·77	3	52·74
Silica	1				
Oxide of Manganese	1				

It appears very probable on a first inspection that this fossil must be a double chromate; but when we compare the analysis of Laugier, Klaproth, and Vauquelin, which do not materially differ nor exhibit any particular loss, though they reduce the chromium to the weight of the green oxide obtained in the analysis, we immediately perceive that this mineral cannot contain chromic acid, because for 53 per cent. green oxide, there must in that case be a loss of 15·77 per cent. from the oxygen which this chromic acid must have given out before becoming an oxide. I have ventured to call the mineral *chromis*, though I am well aware that an oxide exists between the acid and the green oxide, and that it is possible that it also gives combinations where it constitutes the electro-negative ingredient. I call the mineral *subchromis*, because a neutral chromite must contain three times the oxygen of the base, for this reason, that the green oxide contains three volumes of oxygen. This mineral therefore consists, agreeably to the exposition, of two particles *subchromis ferricus*, and one particle *subchromis aluminicus*.

Another similar mineral which Klaproth analysed (Beyträge, iv. 132) seems to consist of four particles of the former to one particle of the latter. The analysis however does not exactly correspond to any calculation. I must remark that the specimens of this mineral which I have had opportunities of examining have not had the smallest influence on the magnetic needle, and therefore could not have contained protoxide of iron.

12*th Order.* Tungstates.

1st Species. *Subwolframias ferrico-manganicus*—Wolfram. Analysed by Vauquelin and Hecht, Journal de Min. No. 19, 18.

Tungstic Acid	67·00	contain oxygen	= 13·40	8	69·40
Oxide of Iron......	18·00		5·40	3	16·95
Oxide of Manganese	6·25		1·87	1	5·64
Silica..............	1·50				
Loss...............	6·95				

I have elsewhere shown that in neutral tungstates the acid contains six times the oxygen in the base. This salt is therefore a *substungstate*. Its composition is $Mg\,O^3 + W\,O^6$ with $3\,F\,O^2 + 3\,W\,O^6$.

13*th Order*. Siliciates.

1st Species. *Supersilicias ferricus*—Crystallized brownish-red iron. Analysed by Buchholz, Journal für die Chemie und Physique, vi. 156.

Silica...............	76·83	contain oxygen	— 38·94	6	78·77
Oxide of Iron......	21·67		6·50	1	21·23
Oxide of Manganese	0·25				

Hence it is $= F\,S^6$.

2d Species. *Trisilicias ferrosus*. See the example of single siliciates. $= F\,S^3 + 2\,Ag$.

3d Species. *Silicias ferroso-aluminicus*—A black mineral from Gillinge without a name. Analysed by Hisinger, Afh. i Fys. Kem. och Mineral. iii. 306.

Silica	27·5	contain oxygen	=13·65	5	27·17
Protoxide of Iron	47·8		10·89	4	47·38
Alumina	5·5		2·57	1	5·77
Water	11·75		10·56	4	12·28
Oxide of Manganese	0·97				

The quantity of oxide of iron in this mineral is determined by the weight of the oxide when burnt with oil. The original has therefore 51·5 for oxide of iron, which corresponds to 48 per cent. protoxide of iron. The composition of this mineral is expressed by $A S + 4 f S + 4 Aq$.

4th Species. *Silicias ferroso-magnesieus*—Chrysolite. Analysed by Klaproth, Beytr. i. 110.

Silica	39·0	contain oxygen	= 19·36	5	40·32
Magnesia	43·5		16·5	4	42·18
Protoxide of Iron	17·6		4·02	1	17·35

Klaproth obtained in the analysis of this mineral an augmentation of weight of two per cent., which disappears when we reduce, as in the above, the weight of the oxide obtained to the protoxide. This mineral is therefore $= f S + 4 M S$.

5th Species. *Silicias ferroso-calcicus*—Melanite. Analysed by Hisinger, Afh. i Fys. Kem. och Mineral. ii. 157.

Silica	34·53	contain oxygen	= 17·14	2	31·01
Protoxide of Iron *	33·40		7·50	1	33·81
Lime	24·36		6·88	1	27·48
Alumina	1·00				
Loss from heating	0·50				

After allowing for trivial inaccuracies in the result, probably owing to a foreign mixture, this mineral is $= f S + C S$.

6th Species. *Silicias ferrico-calcicus*—A garnet shaped mineral. Analysed by Bucholz.

Silica	34·00	contain oxygen	= 16·89	2	33·5
Oxide of Iron	25·00		7·5	1	27·0
Lime	30·75		8·4	1	28·5
Alumina	2·00				
Oxide of Manganese	3·50				
Carbonic Acid and Water	4·25				

The presence of the carbonic acid in this mineral betrays a slight mixture of carbonate of lime. It is in other respects $F S + C S$. Hence it appears that the 5th and 6th species differ merely in the degree of oxidation of iron.

7th Species. *Silicias ferroso-calcicus* with *Silicias aluminicus*—Black garnet, Melanite. Analysed by Klaproth.

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* Calculated from the oxide burnt with oil. The original has 36·50.

Silica	35·5		= 17·62	6	34·59
Protoxide of Iron	22·5	contain	5·13	2	25·13
Lime	32·5	oxygen	9·10	3	30·67
Alumina	6·0		2·8	1	6·11
Oxide of Manganese	0·4				

This mineral is therefore $= A S + 2 f S + 3 C S$.

8th Species. *Silicias manganico-ferricus* with *Subsilicias aluminicus*—Garnet-shaped mineral from Langbanshyttan. Analysed by E. Rothoff, Afh. i Fys. Kem. och Mineral. iii.

Silica	35·0		= 17·37	6	34·46
Oxide of Iron	26·0	coutain	7·8	3	27·37
Alumina	24·7	oxygen	11·6	4	23·92
Oxide of Manganese	8·6		2·6	1	8·08
Lime	0·25				
Soda	1·05				
Carbonic Acid	2·00				

This mineral therefore consists of $Mg S + F^3 S + 4 A S$.

9th Species. *Silicias aluminico-ferricus* with *Bisilicias calcicus*—Aplome. Analysed by Laugier, Ann. du Musée d'Hist. Nat. ix. 271.

Silica	42·0	contain oxygen	= 20·84	5	43.96
Oxide of Iron	14·5		4·35	1	14·00
Lime	14·5		4·06	1	15·34
Alumina	20·0		9·35	2	18·40
Oxide of Manganese	2·0				
Loss by heating to redness	2·0				

This mineral is therefore $C S^2 + F S + 2 A S$.

This exposition seems to demonstrate that the double siliciaté of iron and alumina, like many other siliciates, especially siliciates of lime, magnesia, and manganese, may form garnet-shaped minerals, in the same manner as sulphate of alumina forms with potash and with ammonia such similar salts, that we often take the latter for alum.

Siliciates of iron occur in very great abundance in minerals, for example, in mica, asbestus, tremolite, tourmaline, actinolite, chlorite, prehnite, &c. but in the present state of chemical analysis it is altogether impossible to calculate the composition of a mineral containing iron with any degree of certainty. Klaproth began to determine the contents of oxide of iron by mixing the oxide obtained in the analysis with oil, and burning it afterwards in a vessel half covered, on the supposition that the oil would always reduce the oxide to a definite degree, to which the result of the analysis could then be compared. But this procedure is so inaccurate that we never can depend upon the proportion of iron found; for the oxide of iron is reduced by the oil, in a slight burning, not merely to a protoxide but to a metal. If this burning be continued with the access of air, the metal is again oxidated, and usually forms *oxidum ferroso-ferricum;* but we can never calculate on this taking place completely, or be sure that it has in no degree been over-oxidated. It would be better therefore, in all future analyses, to determine the contents of iron from the weight of the red oxide. In all the calculations of minerals containing protoxide, which I have already adduced, I have made a correction, founded on the supposition, that what in the result of the analysis is given as derived from oxide of iron burnt with oil was *oxidum ferroso-ferricum,* which contains 28·14 per cent. oxygen, and I am of opinion that in most cases we shall in this way come pretty near to the truth.

But there remains another question in mineral analysis much more difficult of solution. In what degree of oxidation does this iron appear in the mineral? It is absolutely necessary for scientific mineralogy to find a method to determine this. The iron may, for instance, be partly protoxide, partly *oxidum ferroso-ferricum*, probably in more than one proportion between both oxides, and partly peroxide. When this latter appears, it is usually most easily recognizable, especially from the colour of the mineral, which is then yellow and red, or gives a powder of that colour: but then to distinguish between the two former from the colour is difficult if not impossible. It is true, for example, that *sulphas ferrosus* has a blue-green colour, where *sulphas ferroso-ferricus* has a grass-green one; but this proves nothing for other cases; for *prussias ferrosus* is white, whereas *prussias ferroso-ferricus* is dark blue. I must therefore recommend it to those who occupy themselves with the analysis of minerals, to endeavour to find out secure means for recognizing the state of oxidation in which the iron is found in the minerals. The same observation applies to manganese. (See farther, Appendix IV.)

14*th Order*. Tantalates.

1st Species. *Tantalas manganico-ferricus*, (*Manganoso-ferricus ?*) — Tantalite-columbite. The analyses by Wollaston, Klaproth, and Vauquelin.

Oxide of Columbium	85	80 *	88	83
Oxide of Iron	10	15	10	12
Oxide of Manganese	4	5	2	8

We see that these results revolve round a common central point; although no calculation can be made, as long as neither the quantity of oxygen in oxide of tantalum is known, nor the degree of oxidation of the two other metallic oxides is determined.

2d Species. *Subtantalas yttrico-ferrosus*—Yttro-tantalite. Analysed by Vauquelin.

Oxide of Tantalum	45
Oxide of Iron and Yttria	55

From this incomplete experiment we can only discover that the above is a tantalate, and therefore it must be a subtantalate.

15th *Order*. Titaniates.

1st Species. *Titanias ferrosus*—Menachanite, Titanium-sand. Analysed by Klaproth, Beytr. ii. 231.

Oxide of Titanium	45·25	100
Protoxide of Iron	51·00	113·3

2d Species. *Subtitanias triferrosus*—Titanic-iron, compact magnetic iron-stone. Analysed by Klaproth, Beytr. ii. 234.

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* Analysis of Columbite.

Oxide of Titanium	22	100
Protoxide of Iron	78	354

3d Species. *Subtitanias seferrosus*—Sandy magnetic iron-stone. Analysed by Klaproth, Beytr. v. 210.

Oxide of Titanium	14·0	100
Protoxide of Iron	85·5	610

4th Species. *Titanias ferrico-manganicus*—Nigrin. Analysed by Klaproth, Beytr. ii. 238.

Oxide of Titanium	84
Oxide of Iron	14
Oxide of Manganese	2

So long as the composition of oxide of titanium is not sufficiently ascertained, the value of these analyses cannot be determined. From the analysis by Klaproth of the protoxide of titanium, we see that the quantities of protoxide of iron are increased nearly as 1, 3, 6. But when we look into the analytical method, we find that the quantity of the protoxide is determined in the manner already mentioned by me, and must therefore be reduced from *ferroso-ferricum* to *ferrosum*, because the striking magnetic characters of the minerals distinctly show that the iron must be found in it in its lowest degree of oxidation. On the other hand the contents of titanium are determined from the loss, so that in the same proportion that the contents of iron are too great, the contents of titanium have suffered. From a calculated correction, the first species contains 98 parts protoxide of iron for 100 parts oxide of titanium; the second species 286 of the former for 100 of the latter, which is nearly = 1 : 3. But the third species does not correspond with the correction. I have not had an opportunity of seeing the fifth volume of the Beyträge, and therefore cannot say how far the analysis of the third species is so determined towards its result, that the same correction can be applied there, that was applied to the other two.

16*th Order.* Hydrates.

1st Species. *Subhydras ferricus*—Ochre, bog-ore. Consists of $FO^3 + 1\frac{1}{2} H^2 O$.

It appears seldom pure, but is generally blended with *carbonas ferroso-ferricus*, together with *subsilicias ferricus*.

Family of Aluminium.

In proportion as we approach the end of the chain of single bodies, the inflammable minerals become more rare, and the oxidated more various. Nature here exhibits the endless diversity of which she is capable, though she always follows with the utmost strictness the laws of definite proportions in composition. The greater the number of oxides which are combined, the greater is also the number of the proportions in which they admit of combination, and I shall place before the eyes of the reader a proof of the possibility of a great multitude of minute variations in composition in minerals of the same kind, with some probabilities that nature occasionally produces a great number of the combinations possible in our theoretical reasoning. Hence it happens that there may be such considerable differences in the numeral contents of kindred minerals, that they will evidently long baffle our most strenuous endeavours to bring the analysis of minerals to the degree of perfection which is so indispensably necessary for the scientific improvement of mineralogy.

The family which we have before us possesses no order belonging to the inflammable combinations, nor, so far as we at present know with certainty, any pure oxide that is alumina in a combined state. Most systems of mineralogy adopt a class of precious and completely hard stones which they consider as pure alumina. Thus, for example, Klaproth found sapphire to be pure alumina coloured by a little oxide of iron; but Chenevix found by the application of a new analytical method, in the same sapphire, 3¼ per cent. silica, and 7 per cent of it in rubies. It is not probable that these contents of silica are merely accidental. Perhaps these minerals must be considered as subsiliciates in the highest degree of saturation with alumina.

Another class of these hard minerals contains the alumina combined with bodies of a more complete electro-positive nature than alumina; for example, with magnesia in the spinell, and with oxide of zinc in the authomolite. If it hereafter can be shown to be probable that the minute portions of silica found in these are derived from foreign mixtures, then these combinations would be true *aluminiates*, in which the alumina supplies the place of the acid, and belong therefore no longer to the family of alumina, but to those of their bases. The affinity between these minerals has the same ground as the affinity between sulphate of magnesia and sulphate of zinc, or between sulphate of barytes and sulphate of strontian.

According to Ekeberg, the authomolite contains.

Alumina........	60·00	contain	= 28·2	12	or 6
Oxide of Zinc..	24·25	oxygen	4·8	2	1
Oxide of Iron..	9·25 as protoxide		2·0	1	
Silica...........	4·75		2·2	1	

This mineral can be considered in various ways. If we do not attend to the iron and the silica, it would then be an *alumias zincicus*, in which the alumina contains six times the oxygen of the oxide of zinc, and which might be coloured by silicias ferrosus.

On the other hand, it may again be composed of a double aluminate of zinc and iron, that is, *trialuminias ferroso-zincicus*, so that the alumina in all these single combinations contains three times as much oxygen as the body with which it is combined. In this case the composition is $FA^3 + 2\,ZiA^3 + A^3S$.

Spinell from oker consists, according to my analysis of it, of

Alumina.........	72·25	contain	= 33·93	24	or 6
Magnesia.........	14·63	oxygen	5·56	6	1
Silica	5·48		2·64	3	
Oxide of Iron...	4·26 as protoxide		0·95	1	

The alumina is here again evidently in the same proportion to the magnesia as in the foregoing to the oxide of zinc, notwithstanding that the quantities of the oxide of iron and the silica are not in the same relative proportion as there. This circumstance furnishes another probability in favour of the idea that these minerals are true sealuminiates of oxide of zinc and magnesia, to the constitution of which, oxide of iron and silica perhaps belong only as mechanical mixtures, constituting a part of the structure of the crystal. Future experiments must throw light on this.

1*st Order.* Sulphates.

1st Species. *Subsulphas aluminicus*—Native alumina from Halle, in Germany; from Sussex, in England. In this fossil, the alumina contains the same oxygen with the acid, and the crystal water three times as much.

2d Species. *Sulphas aluminico-kalicus*—Native alum. Consists of three particles sulphate of alumina for one particle sulphate of potash, and 24 particles water.

2*d Order.* Fluates.

1st Species. *Subfluas aluminicus*—Babington's wavellite. Davy's analysis states its composition to be alumina, water, and fluoric acid spar. The proportion of the water to the alumina proves that what Davy took for pure alumina also contained fluoric acid.

2d Species. *Fluas aluminico-natricus*—Chrysolite. Analysed by Klaproth and Vauquelin.

Soda..........	36·9	contain oxygen	= 9·5	32	contain oxygen	= 8·2
Alumina......	24·0		11·2	21		9·2
Fluoric Acid and Water	40·1			47		

The difference in the results of the two analyses is perhaps a proof that neither of them is perfectly correct. In the mean time they approach so near to each other, that we perceive both bases must contain the same oxygen. That the soda turns out less is owing to the extensiveness of the operation which is necessary to bring it out, and which renders loss inevitable. In the fluates the salt contains the same oxygen with the base. Let us now assume that the salt is composed of one particle neutral fluate of soda, one particle fluate of alumina, and one particle water, its numerical composition will then be, according to calculation,

Soda.	40.00	
Alumina	21·73	
Fluoric Acid.	26·66	= 38·27
Water	11·61	

with which the analysis of Klaproth coincides, so far as to constitute a good approximation, especially, as was before stated by me, when we consider that the alumina in the analysis of most minerals containing fluoric acid turns out always too high from a small quantity of retained fluoric acid.

3d Order. Fluo-siliciates.

This order is composed of the topaz family. It is known that fluoric acid possesses the property of uniting with boracic acid and silica, and forming peculiar acid gases which may be called *acidum boracico-fluoricum*, *acidum silico-fluoricum*, and their combinations with bases, fluo-borates, fluo-siliciates. The fluo-borates have been described in a highly interesting manner by Thenard and Gay-Lussac. Fluo-siliciates however, though they are much more remarkable, and though they have long been known, have never been the subject of a similar theoretical examination. Richter has long ago described many fluo-siliciates, (Neue Gegenstände, St. iv. 53—76,) namely, those of potash, soda, barytes, lime, and magnesia; and John

Davy has lately with great accuracy examined both *acidum silico-fluoricum* and *fluo-silicias ammonicus*. He found that 100 parts of fluoric acid combine with 159 parts of silica, and that these 259 parts can combine with 84·33 parts of ammonia, and from these data we can calculate the quantities of every other basis which is capable of saturating this double acid.

However I must remark that after it has formed a salt, this salt must be considered as double, consisting of fluate and siliciate. Hence it must happen that one particle of fluate may be combined with 2, 3, 4, &c. particles of the siliciate, in the same manner as one particle of the fluate may be combined with 1, 2, 3, &c. particles of the bisiliciate, and also that a particle of the subfluate may be combined with one or more particles of the siliciate, with many other variations. The diversity which prevails in the analytical results obtained in the topaz family, induced me to calculate some of these possibilities, and to arrange them in numbers for the purpose of comparison with the analyses.

I have assumed as the ground of this calculation, according to experiment, in so far as its precision applies to the point, that the quantities of fluoric acid, silica, and alumina, which contain equal quantities of oxygen, are to one another = 100, 159, 163. In the following formulæ I have marked the fluoric acid with the sign *Fl.*

Formulæ	$A\,Fl^2 + A\,S^3$.	$A\,Fl + A\,S$.	$A\,Fl + 2\,A\,S$.
Alumina...	38·62	55·4	53·91
Silica......	37·68	27·2	35·06
Fluoric acid	23·70	16·4	11·03

Formulæ	$A\,Fl + 3\,A\,S$.	$A\,Fl + 4\,A\,S$.	$A\,Fl + 5\,A\,S$.
Alumina...	53·07	52·55	52·21
Silica......	38·80	40·30	42·44
Fluoric acid	8·13	7·15	5·35

Formulæ	$A\,Fl + 6\,A\,S$.	$2\,A\,Fl + A\,S$.	$A^2\,Fl + A\,S$.
Alumina...	52·17	47·6	65·36
Silica......	43·50	23·2	21·26
Fluoric acid	4·33	29·2	13·38

Formulæ	$A^2\,Fl + 2\,A\,S$	$A^2\,Fl + 3\,A\,S$.	$A^2\,Fl + 4\,A\,S$.
Alumina...	60·93	58·55	57·09
Silica	30·00	34·27	31·10
Fluoric acid	9·07	7·18	5·81

Formulæ	$A \cdot Fl + A\,S^3$.	$A^2\,Fl + 2\,A\,S^3$.	$A^5\,Fl + 3\,A\,S^3$.
Alumina...	44·56	47·10	55·30
Silica......	42·20	45·5	40·46
Fluoric acid	13·24	7·4	4·26

The reality of the two last formulæ may perhaps at first sight be doubted. But I am induced to consider it highly probable that one particle of fluoric acid, by means of its very strong affinity, may retain two particles of alumina with equal if not stronger power than that with which two particles of silica retain one particle of alumina.

We easily perceive that the differences between the numeral contents in these calculated compositions are so minute, that the manner in which these minerals have hitherto been analysed can determine nothing relative to their intimate composition, or the formula to which they belong.

The topaz family includes pycnite, stangenstein, schorlous beryl, pyrophysalite, precious and common topaz. The following is the analycal result:

	Schorlous beryl.			Pyrophysalite.
	Bucholz.	Vauquelin.	Klaproth.	Hisinger.
Alumina	48	52·0	49·5	53·25
Silica	34	36·8	43·0	32·88
Fluoric acid	17	5·8	4·0	10·00

	Saxon.	Siberian.		Yellow Brasilian.	White Topaz.	
	Klaproth.	Vauquelin.		Klaproth.	Vauquelin.	
Alumina	59	49	48	47·5	47	50
Silica	35	29	30	44·5	28	29
Fluoric acid	5	20	18	7·	17	19

Very few of these results coincide with any of the calculated formulæ; but let any one compare merely the analyses of Klaproth and Vauquelin of Saxon and yellow Brazilian topaz, and he will immediately perceive that some hidden error must lurk at the bottom of these differences. For example, Klaproth found that the Saxon topaz contained only five per cent. fluoric acid, but that by a strong red heat, especially when assisted by the bellows, it lost as much as 22 per cent. which is nearly twice as much as ought to be the case if this five per cent. acid had made its escape saturated with silica. In the analysis of finbo-topaz, known by the name of pyrophysalite, which was made by myself and M. Hisinger, (Afhl. i Fys. Kem. och Min. i. 114,) we remarked that when the alumina, which after solution in caustic potash was precipitated by sal ammoniac, was gently heated to redness, it went through no unusual change; but that when it was exposed to a white heat in the crucible, and the lid was suddenly taken off, the mass emitted smoke, and the lid was always attached to the crucible by a sublimate which we found to be a salt of alumina soluble in water, and probably neutral fluate of alumina; 119 parts of burned alumina, which had been heated to redness, lost by this treatment nine parts in a white heat. This seems to prove therefore that so long as the fluoric acid is not separated we always obtain a part of it, notwithstanding the surplus of the alkaline precipitant in the midst of the alumina, and that when it is gently heated to redness the proportion of alumina turns out too high, and when it is exposed to between both the bases, and the decided inclination of the glucina to form supersalts prevails also in this instance, as it takes, in relation to the oxygen which it contains, twice as much silica as alumina. In the analysis of the beryl the proportion of the contents of silica to the bases comes nearer than in the emerald, while on the other hand the relative quantities of the bases in the latter are more correct than in the former, which gives too much glucina. The mineral is therefore $G S^4 + 2 A S^2$.

2d Species. *Silicias aluminicus* with *Bisilicias beryllicus*—Euclase. Analysis by Vauquelin, Haüy's Traité de Mineralogie, ii. 532.

Silica	36	contain oxygen	= 17·28	4	38·04
Alumina	19		8·87	2	20·10
Glucina	15		4·66	1	15·16
Water	27		23·82	5	26·72
Oxide of Iron	3				

We see from this analysis that the bases in this mineral are in the same proportion to each other as in the preceding, and that the glucina takes also here double of the silica in relation to the same quantity of oxygen, that the alumina does. The proportion of oxygen in glucina will be found by the reader determined in Appendix V. This mineral is therefore $G S^2 + 2 A S + 5 Aq$.

2d Genus. *Silicias aluminico-calcicus.*

1st Species. *Trisilicias aluminico-calcicus*—Mealy Zeolite. Analysed by Hisinger, Afh. i Fys. Kem. och Min. iii. 315.

Silica	60·0	contain oxygen	= 29·78	12	59·47
Alumina	15·6		7·28		15·80
Lime	8·0		2·25	1	8·80
Water	11·6		10·14	4	11·13
Oxide of Iron	1·8				

This mineral is $C S^3 + 3 A S^3 + 4 Aq$.

2d Species. *Bisilicias aluminico-calcicus*—Laumonite. Analysed by Vogel, Journal de Physique, 1810, 64.

Silica	49·0	contain oxygen	= 24·42	10	48·90
Alumina	22·0		10·27	4	20·15
Lime	9·0		2·52	1	8·83
Water	17·5		15·44	6	16,27

This mineral is $C S^2 + 4 A S^2 + 6 Aq$.

3d Species. *Silicias aluminico-calcicus*—Columnar Scapolite. Analysed by Laugier, Journal de Physique, lxviii. 36.

Silica	45·0	contain oxygen	= 21·60	4	42.06
Alumina	33·0		15·41	3	34.06
Lime	17·6		4·92	1	18·86
Soda, Potash Oxide of Iron	3·0				

This mineral is therefore = $C\,S + 3\,A\,S$, impure from small quantities of alkaline siliciates.

4th Species. *Silicias aluminicus* with *Trisilicias calcicus*—Needle zeolite. Analysed by Vauquelin, Journal de Min. No. 44, 596.

Silica	50·24	contain oxygen	= 24·00	8	47·71
Alumina	29·30		13·72	5	31·69
Lime	9·46		2·75	1	10·55
Water	10·00		8·82	3	10·05

This mineral is therefore $C\,S^3 + 5\,A\,S + 8\,Aq$. Hisinger found in a shapeless zeolite from Tandsla in Södermanland, silica 51·5, alumina 30, lime 8, and water 5. It seems to be the same mineral with only two particles water.

5th Species. *Silicias aluminicus* with *Bisilicias-calcicus*—Shapeless Zeolite from Borkhult. Analysed by Hisinger, Afh. i. Kem. Fys. och Min. iii. 309.

Silica	46·40	contain oxygen	= 23·07	5	46·18
Alumina	29·00		13·04	3	29·46
Lime	17·14		4·80	1	16·36
Oxide of Iron	0·70				
Lost by a red heat	3·20				

This mineral is $C\,S^2 + 3\,A\,S$.

3d Genus. *Silicias aluminico-bariticus.*

1st Species. *Bisilicias aluminico-bariticus*—Cross-stone Harmotome from Oberstein. Analysed by Tassaert.

Silica	47·5	contain oxygen	= 23·50	14	46·50
Alumina	19·5		9·17	6	21·17
Barytes	16·0		1·68	1	15·73
Water	13·5		11·91	7	13·40

This mineral is $B S^2 + 6 A S^2 + 7 Aq$.

2d Species. *Bisilicias aluminicus* with *quadrisilicias bariticus*—Cross-stone from Andreasberg. Analysed by Klaproth, Beytr. ii. 83.

Silica	49	contain oxygen	= 24·30	12	47·19
Alumina	16		7·52	4	16·81
Barytes	18		1·89	1	18·62
Water	15		13·23	7	15·38

This mineral is $BS^4 + 4 AS^2 + 7 Aq$. This analysis requires an accurate revision, notwithstanding its complete coincidence with the formulæ, because the differences are altogether so minute that they may possibly have been errors of experiment, and these two species have therefore perhaps the same chemical combination.

4th Genus. *Silicias aluminico-natricus.*

1st Species. *Silicias aluminicus* with *Trisilicias* *natricus*—Mesotype. Analysed by Klaproth, Beytr. v. 49.

Silica	48·00	contain oxygen	= 23·84	6	49·02
Alumina	24·25		11·32	3	26·06
Soda	16·50		4·21	1	15·77
Water	9·00		7·94	2	9·15
Oxide of Iron...	1·75				

This mineral is $N S^3 + 3 A S + 2 Aq$.

2d Species. *Silicias aluminico-natricus*—Electric Schorl. Analysed by Klaproth, Beytr. v. 90.

Silica	43·50	contain oxygen	= 21·58	10	44·07
Alumina	42·25		19·73	9	42·13
Soda	9·00		2·30	1	8·55

This mineral is $N S + 9 A S$.

5th Genus. *Silicias aluminico-kalicus.*

1st Species. *Trisilicias aluminico-kalicus*—Common Felspar. The most probable composition of common felspar, so far as we can calculate it from the many analyses of it which we possess, is, that the alumina bears the same proportion to the potash as in alum, and that the silica contains three times the oxygen of the base. The following is therefore a comparison between the calculated and experimental results of the composition of Felspar. Analysis by

		Vauquelin.	Klaproth.	Rose.	Calculated Result.	
Silica	64[*]	62·83[†]	68·0[‡]	66·75[§]	66·26	12
Alumina	20	17·02	15·0	17·50	17·61	3
Potash	14	13·00	14·5	12·00	16·13	1
Lime	2	3·00		1·25		
Protoxide of Iron		1·00		0.75		

I am therefore disposed to believe that we may with some degree of certainty consider common felspar as $K\,S^3 + 3\,A\,S^3$.

2d Species. *Trisilicias kalico-aluminicus*—Lepedolite from Utön. Analysed by Hisinger, Afh. i Fys. Kem. och Mineral. iii. 398.

Silica	61·60	contain oxygen	= 30·60	21	63·39
Alumina	20·61		9·72	6	19·30
Potash	9·16		1·56	1	8·82
Water	1·86		1·63	1	1.69
Oxide of Manganese	0·50				
Lime	1·60				

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[*] Adularia, Hauy's Traité de Mineral. ii. 592, $K\,S^4\ 44\ A\,S^2$?

[†] Emerald-green Siberian felspar, Bull. de la Soc. Phil. An. 7, No. 24, p. 185.

[‡] From Drachenfels, Beytr. v. 18, $K S^4\ 3 + A\,S^2$?

[§] Flesh-coloured felspar from Lemnitz.

The oxygen of the silica is not fully 21 times that of the potash, but the error in the proportion of potash must be very trifling, because in the calculation it is multiplied 21 times, so that we may pretty confidently state this mineral $K S^3 + 6 A S^3 + Aq$.

5th Species. *Bisilicias aluminico-kalicus*—Leucite. If this mineral is $K S^2 + 3 A S^2$ its composition will then be (Klaproth's analysis, Beytr. ii. 54.)

Silica..	53·50	contain oxygen	= 26·55	8	55·45
Alumina..........	24·25		11·32	3	22·10
Potash............	29·09		3·41	1	20·25

which come as near to one another as possible, particularly when we observe that in almost all single siliciates the proportion of silica comes out too low, which either happens from a small loss through the solubility of the earth in the analysis, or from taking the proportion of oxygen too low in the calculation of the composition of the silica.

3d Subdivision, Triple and Complex Siliciates.

1st Genus. *Silicias aluminicus* with *Silicias kalicus* and *Silicias ferricus*. Prehnite family.

1st Species. *Foliated Prehnite* from the Cape. Analysed by Klaproth, Beol u. Entd. der Naturf fr. z. Berlin.

Silica	40·93	contain oxygen	= 19·65	13	41·93
Alumina	30·33		14·15	9	30·31
Lime	18·33		5·12	3	17·16
Oxide of Iron	5·66		1·69	1	5·25
Water	1·63		1·68	1	1·85

This mineral is $F S + 3 C S + 9 A S + A q$.

2d Species. *Radiated Prehnite.* Analysed by Laugier, Ann. du Mus. d'Hist. Nat. iii. 205.

Silica	42·5	contain oxygen	= 21.0	22	41·8
Alumina	28·5		13·3	15	29·0
Lime	20·4		5·6	6	20·0
Oxide of Iron	3·0		0·9	1	3·0
Water	2·0		1·8	2	2·1
Alkali	0·75				

This mineral is $F S + 6 C S + 15 A S + 2 A q$.

3d Species. *Koupholite.* Analysed by Vauquelin, Haüy's Traité de Min. iv. 373.

Silica	48	contain oxygen	= 23·84	20	49·23
Alumina	24		11·93	9	23·93
Lime	23		5·44	5	21·90
Oxide of Iron	4		1·90	1	3·94

This mineral is $F S + 5 C S^2 + 9 A S$.

2d Genus. *Silicias aluminicus* with *Silicias* *ferricus* and *Silicias kalicus* (sometimes also *Silicias magnesicus*): Mica family.

1st Species. *Window Mica.* Analysed by Klaproth, Beytr. v. 69.

Silica	48·00	contain oxygen	= 23·00	16	46·00
Alumina	34·25		16·60	12	36·50
Potash	8·75		1·48	1	8·37
Oxide of Iron......	4·50		1·37	1	4·63

This mineral is $KS^3 + FS + 12\,AS$.

2d Species. *Silver Mica* from Zinnwalde. Analysed by Klaproth, *ibid.*

Silica	47·0	contain oxygen	= 22·56	9	45·05
Alumina	20·0		9·58	4	21·25
Potash	14·5		2·46	1	14·60
Oxide of Iron.....	–15·5		4·65	2	16·10

This mineral is $KS^3 + 2\,FS + 4\,AS$.

3d Species. *Black Siberian Mica.* Analysed by Klaproth, Beytr. v. 78.

Silica...............	42·00	contain oxygen	= 20·16	12	41·60
Alumina	11·50		5·37	3	11·08
Lime	10·00		1·70	1	10·18
Oxide of Iron......	22·00		6·60	4	22·48
Magnesia	9·00		3·42	2	9·07

This mineral is $KS^3 + 2\,MS + 3\,AS + 4\,FS$.

Future experiments must determine how far, from the magnesia which it contains, it may constitute a peculiar genus or not.

It is not my intention to affirm that these analyses of triple and complex siliciates, with the formulæ derived from them, may in all respects be depended on; but I give them merely as an example of the manner in which the minerals may probably be composed. The mineralogical analysis is evidently not yet sufficent for the precise determination of these complex bodies, when the proportions in which they may be combined are so numerous, and when we are unacquainted with the proportions in which they principally endeavour to combine themselves. We see, for example, that alumina combines with potash for the most part in such a proportion, that one part of the latter takes three of the former, and that the potash occasionally takes six and sometimes nine particles of alumina; and when we investigate these examples we find that the alumina is most frequently an ingredient in the minerals at the rate of one, three, six, nine, twelve, and fifteen particles, which are multiples of three by two, three, four, and five. Hence we have reason to conjecture that the alumina does not appear in any number, especially above six, which lies between these figures: this conjecture is no doubt merely a probability, but as the means of stimulating to investigation it is not without its worth.

I venture to indulge the hope that the publication of this Essay may possibly lead to a revision of the prevailing system of mineralogy, convinced as I am that this will give fresh life and new properties to the mineral analysis, and be the means of introducing the more general adoption of a greater degree of precision than has hitherto taken place, as the scientific advantages resulting from the utmost degree of accuracy have never yet sufficiently counterbalanced the difficulties which it occasioned to the mineralogical analyst.

APPENDIX I.

GROUNDS OF THE CALCULATIONS.

The calculations which I have cited in the foregoing examples are founded on the determination of the capacity of inflammable bodies for oxygen, which I some time ago published in a separate Treatise printed in Dr. Thomson's Annals of Philosophy, 12th, 13th, and following numbers.

This Treatise cannot yet be in the hands of any Swedish reader, and I shall therefore summarily extract from it what has any relation to the above Mineralogical Essay, and which may be necessary to establish or refute the calculations of mineral analyses.

The cause of chemical proportions must consist in some seemingly mechanical circumstance relative to the elementary bodies in their solitary state, respecting which we must long, in all probability, content ourselves with mere conjectures.

When we represent to ourselves the elements in their original isolated state, we may consider them either;

1st, As *solid bodies* composed of infinitely small particles in a state of concretion, which lie near one another and ocupy a limited space.

2dly, As gases, consisting of parts which fly to the greatest possible distance from each other, and spread themselves out, as it were, equally at their whole distance.

In the first case we may lay down as incontrovertible, that when several elements are combined into one compound body, this must happen in such a way that a small part or particle of the one is combined with one, two, three, or more whole particles of the other, whence we are thus enabled to see a mechanical cause for the multiple proportions.

In the latter case again, as the bodies are considered as gases, we are taught by *experience*, that these are either combined in equal volumes, or a volume of the one gas takes two, three, or more volumes of the other. Hence it follows that what in the one of these cases is called a *particle* is called in the other a *volume*, and that both, so far as respects the doctrine of the chemical proportions, are one and the same, so that in this point of view it is altogether indifferent which of them we follow.

In the foregoing instances I have designedly adhered to the former assumption, notwithstanding it gives rise to difficulties which cannot immediately be solved or removed, because it coincides best with our ordinary manner of seeing and conceiving bodies and their composition.

The *corpuscular theory*, the appellation I shall give to this mode of representation, admits no penetration of bodies in chemical combination, and it allows us to conjecture that their property of attracting each other, and of being chemically combined under a more or less perceptible ignition, is derived from an electrical polarity in the smallest parts, which in different bodies is of different strength, and by which the electrical charge of the one pole has a stronger intensity than that of the other. Hence we perceive (α) a probable cause for the excitation of electricity through the contact of dissimilar bodies, (β) which leads us to infer that a body is electro-positive, or electro-negative according as the one or the other pole prevails, and that in like manner it follows (γ) that in case this speculation is well founded, chemical affinity and polarity of particles are altogether one and the same. I have endeavoured to give a greater extension to these ideas in Nicholson's Journal of Philosophy, Chemistry, &c. vol. xxxiv. page 153.

The difficulties to which the corpuscular theory is subject arise principally from the circumstance, that there are bodies in which all the circumstances at present seem to demonstrate the existence of a half particle, of which however we cannot admit the supposition. The same difficulty applies to the construction in particles of composite bodies, especially where the number of elementary particles is great. This difficulty is less perceptible in unorganic nature, because every composite body is there constituted in such a manner, that one of its ingredients enters only as an ingredient in one particle, and forms the unity or fundamental particle which in the case of great parts is effected by the most electro-positive ingredients, round which we can represent the others analysed in an order that altogether depends on the electrical poles of the fundamental particles. But in organic nature the proportion is altogether different; particles of three, four, and more elements, of which frequently none is unity, or the fundamental particle, are there joined in a compound particle, of which the structure is not so easily conceived in a probable and satisfactory way. Thus, for example, tartaric acid consists of four particles carbon, five particles hydrogen, and five particles oxygen; mucous acid, of six particles carbon, ten particles hydrogen, and eight particles oxygen, &c. However I must observe that difficulties are not refutations, and what cannot be perceived by one person, or at one period, may easily in future investigation be discovered by another person in an after period.

I call the representation of bodies in a gaseous form the *theory of volumes*. It does not admit of all these speculations, and, if I may be allowed to say so, cuts off all farther investigation of that nature, and confines itself within the phenomena which may be proved by experience. I consider it as a leading-string to keep us in the way of truth while we are endeavouring in our investigations to penetrate deeper into the secrets of the corpuscular theory.

As it has thus been established that the unorganic bodies consist of one particle or volume of an elementary body, combined with one or more particles or volumes of another elementary body, it became naturally of the greatest interest for chemistry to know how many particles of each element enter into composite bodies. The solution of this question is difficult, and cannot at present be relied on for all composite bodies. In combinations formed agreeably to the principle of the composition of unorganic nature, we must for this purpose merely investigate the number of volumes of the oxygen in the oxides, and when this has been found, we may easily calculate the number of particles from the usual result of the analyses. In bodies however which are formed agreeably to the principle of the composition of organic nature, this becomes infinitely more difficult, and requires expedients and calculations for which, in a work on the laws for the chemical proportions in organic nature, I have endeavoured to prepare the way, although that work does not apply to the class of minerals which seem to be the remains of former organised bodies.

To determine the weight of every particle of a body, or, what is the same, of its proper weight in the gaseous form, we compare it with that of the oxygen which, according to what I have long before said, is the universal measure in the doctrine of chemical proportions. In the treatise from which this is an extract, I have stated all the experiments on which the weights given are grounded, and I have also endeavoured to determine the boundaries within which the result of the analyses may be probably incorrect, from whence the *minima* and *maxima* are deduced in the following table. That such are not found for the most bodies is not because their weight is so absolutely sure, but because I required more experiments respecting them, from which alone I could give a result.

I have also stated the grounds on which I have ventured to deduce the number of particles of the oxygen in most oxides, but it would lead me too far to give an extract from it in this place.

In the following table, the first column expresses the name of the body; the second the chemical sign, the third the weight of every particle, or the proper weight of the body in the gaseous form compared with that of the oxygen as unity. The fourth and fifth show the minima and maxima when the experiment was performed which gave occasion to them.

TABLE I.

Name.	Sign.	Weight.	Minimum.	Maximum.
Oxygenium	*O.*	100·	—	—
Sulphuricum	*S.*	201·	200·	210·
Phosphoricum	*P.*	167·512	167·3	—
Muriaticum	*M.*	139·56	—	152·7
Fluoricum	*F.*	60·	30·	—
Boracicum	*B.*	73·27	—	—
Carbonicum	*C.*	74·91	73·6	75·5
Nitricum	*N.*	79·54	75·5	—
Hydrogenium	*H.*	6·636	—	7·63
Arsenicum	*As.*	839·9	—	852·2
Molybdænum	*Ms.*	601·56	—	—
Chromium	*Ch.*	708·05	—	—
Wolframium (*Tungsten*)	*W.*	2424·24	—	—
Tellurium	*Te.*	806·48	—	819·
Stibium	*Sb.*	1613·	—	—
Tantalum	*Ta.*	—	—	—
Titanium	*Ti.*	1801 ?	—	—
Silicium	*Si.*	304·35 *	202·9	—
Zirconium	*Zi.*	—	—	—
Osmium	*Os.*	—	—	—
Iridium	*I.*	—	—	—
Rhodium	*R.*	1490·3	—	—
Platinum	*Pt.*	1206·7	—	—
Aurum	*Au.*	2483·8	—	2500.
Palladium	*P.*	1418·	—	—
Hydrargyrum	*Hd.*	2531·6	2503·1	2536·1
Argentum	*Ag.*	2688·17	—	—
Cuprum	*Cu.*	806·45	800·	—
Niccolum	*Ni.*	733·8	—	—
Cobaltum	*Co.*	732·61	—	—
Bismuthum	*Bi.*	1774·	—	—
Plumbum	*Pb.*	2597·4	—	2620·2
Stannum	*Sn.*	1470·59	—	—

* In the Table formerly published by me, I calculated the contents of the oxygen of the silica at 48 per cent., agreeably to my direct experiment on siliciated iron. I have here calculated it according to the data formerly laid down by me, on the supposition that it contains three volumes of oxygen, which seems to follow from the composition of most siliciates.

TABLE I.—*continued.*

Name.	Sign.	Weight.	Minimum.	Maximum.
Ferrum................	*Fe.*	693·64	—	—
Zincum................	*Zn.*	806·45	—	—
Manganium............	*Mn.*	711·57	—	—
Uranium..............	*U.*	3141·4 *	—	—
Cerium................	*Ce.*	1148·8	—	—
Yttrium...............	*Y.*	881·66	—	—
Beryllium (Glucinum)..	*Be.*	683·3 †	663·3	—
Aluminium............	*Al.*	343·	—	228·
Magnesium............	*Ms.*	315·46	30·163	321·92
Calcium..............	*Ca.*	510·2	—	—
Strontium............	*Sr.*	1418·14	—	—
Barytium.............	*Ba.*	1709·1	—	—
Sodium...............	*Na.*	579·32	—	—
Potassium............	*K.*	978·0	—	—

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* Uranium, since the formation of my first Table, has been investigated by M. Schoüberg. (See his Diss. de Conjunctione Chemica ejusque Rationibus, Ups. Oct. 16, 1813, p. 18—24.) As I had opportunities of witnessing the accuracy with which M. Schoüberg carried on his experiments, I consider them as entitled to be somewhat depended on. He found that 100 parts muriate of uranium consist of

Acid....................	16·77	180·0
Protoxide...............	93·08	489·3

Hence it follows that this protoxide consists of

Uranium................	94	100·000
Oxygen.................	6	6·373

He farther found that 100 parts yellow oxide lost, when heated to redness, from 2·7 to 2·9 per cent of weight, and remained protoxide; whence it follows that the metal takes precisely one and a half times the quantity of the oxygen which is in the protoxide, and consists of

Uranium..............	91·2	100,00
Oxygen...............	8·73	9·56

And must contain three volumes of oxygen.

† The contents of oxygen in glucina are determined in Appendix V.

APPENDIX II.

TABLE II.

Showing the Number of Particles of the Oxygen in the Oxides hitherto known, taking the Radicals as a Particle.

Acidum Sulphuricum	3
——— Sulphurosum	2
——— Phosphoricum	2
——— Muriaticum	2
Superoxide Muriatosum	3
——— Muriaticum (Davy's Euchlorine)	4
Acidum Oxymuriaticum	8
——— Nitricum	6
——— Nitrosum	4
Oxidum Nitricum	3
——— Nitrosum	2
Suboxidum Nitricum	1
Acidum Fluoricum	2
——— Boracicum	2
——— Carbonicum	2
Suboxidum Carbonicum	1
Aqua	½
Acidum Arsenicum	6
——— Arsenicosum	4
Oxidum Arsenicum	3
Acidum Molybdicum	3
Acidum Molybdosum	2
Oxidum Molybdicum	1
Acidum Chromicum	6
Oxidum Chromicum	4
——— Chromosum	3
Acidum Wolframicum	6
Oxidum Wolframicum	4
Acidum Stibicum	6
——— Stibiosum	4
Oxidum Stibicum	3
——— Telluricum	2
Silicia	3
Oxidum Rhodicum	3
——— Rhodeum	2
——— Rhodosum	1
——— Platinicum	2
——— Platinosum	1
——— Auricum	3
——— Aureum	2
——— Aurosum	1
——— Palladicum	2
——— Argenticum	2

TABLE II.—*continued.*

Oxidum Hydrargyricum	2	Oxidum Manganicum	3
——— Hydrargyrosum	1	——— Manganosum	2
——— Cupricum	2	Suboxidum Manganicum	1
——— Cuprosum	1	Oxidum Uranicum	3
Superoxidum Niccolicum	3	——— Uranosum	2
Oxidum Niccolicum	2	Oxidum Cericum	3
Superoxidum Cobalticum	3	——— Cerrosum	2
Oxidum Cobalticum	2	Yttria	2
——— Bismuthicum	2	Beryllia (Glucina)	3
Superoxidum Plumbicum	4	Alumina	3
——— Plumbosum	3	Magnesia	2
Oxidum Plumbicum	2	Calcaria	2
——— Stannicum	4	Strontia	2
——— Stanneum	3	Baryta	2
——— Stannosum	2	Superoxidum Natricum	3
——— Ferricum	3	Natrum	2
——— Ferrosum	2	Superoxidum Kalicum	6
——— Zincicum	2	Kali	2
Superoxidum Manganicum	4		

With the assistance of this and the former Table, the numerical composition of every one of these oxides may be calculated. Suppose we want to calculate the composition of oxide of gold, *(oxidum auricum:)* in the first Table we find that a particle of gold weighs 2483·8, and a particle of oxygen 100; and from the second Table, that the oxide of gold consists of 2483·8 gold + 300 parts oxygen; consequently a particle of the oxide of gold must weigh 2783·8.

But as 2783·8 : 300 = 100 : 10·78, consequently the oxide of gold contains 10·78 per cent. of oxygen. Or, if we say 2483·8 : 300 = 100 : 12·077, we find that 100 parts gold take 12·077 parts oxygen.

In this manner the reader will find in these Tables data for calculating all the mineral bodies hitherto known, except combinations of tantalum, zircon, osmium, iridium, and I may add titanium, the volume of which I endeavoured to calculate according to an experiment, of a very unsatisfactory nature certainly, by Richter with muriate of titanium. (See his Neue Gegenstände, x. 121, et seq.)

APPENDIX III.

OF THE CHEMICAL SIGNS.

In the foregoing Treatise I have used two kinds of signs which I called chemical and mineralogical: the latter I have already sufficiently described. I shall now say a few words respecting the former.

In order to express without a multitude of words the composition of a body with respect to the chemical proportions, I avail myself of formulæ in which each body is denoted by the letter which is placed opposite it in Table I.

The rule for the formation of this sign is as follows: select the initial letter of the Latin name of the body; but if the name of more than one body should begin with the same letter, and one of these bodies should belong to the class of metalloids, then the letter is used without addition for this. For the metals we add the next letter; or should it be common, then we add in its place the first consonant which is not common to both names. For example, C = Carbonicum, Cu = Cuprum, Co = Cobaltum, S = Sulphurium, Sb = Stibium, Sn = Stannum, &c.

A figure to the left of the sign shows how many particles of the body is wished to be expressed; for example, $S + 3\,O$, sulphuric acid; $Fe + 4\,S$, common iron pyrites. When we wish to express a composite body as a particle, we then place the figure which expresses the number of particles which it contains of either element to the right of this sign, like an algebraical exponent; as, for example, in $S\,O^3 + Cu\,O$ = sulphate of copper. A figure to the left of the composite particle multiplies the whole, and the contents; that is, multiplies all the bodies within the same plus sign: for example, $2\,S\,O^3 + Cu\,O^2$ = persulphate of copper; the number 2 denotes that the acid in the salt contains not only two particles of sulphur but six particles of oxygen, &c.

In expressing more compound bodies, it answers best to exclude the sign of the oxygen, and by points above the radical to denote that it is an oxide, and how many volumes of oxygen it contains. But from this we must except the oxides which may contain two volumes radical for one volume oxygen; for example, water, where we must add the sign of the oxygen. Thus for example, we place for $2\,S\,O^3 + Cu\,O^2$, $\overset{\cdots}{S}{}^2\,\ddot{Cu}$, by which the formula is shortened, a circumstance of great importance in double salts. The composition of alum for example may be expressed in the following manner: $\ddot{K}\,\overset{\cdots}{S}{}^2 + 3\,\overset{\cdots}{Al}\,\overset{\cdots}{S}{}^3 + 24\,H^2\,O$, from which we perceive that this salt in its crystallized state contains not less than 68 particles oxygen for one particle potash, &c.

I cannot however yet affirm that these formulæ supply the place of the mineralogical, because our knowledge of the number of particles of oxygen in many oxides cannot be considered as certain, and it is therefore a strong advantage in favour of the mineralogical formulæ that they may be used without this circumstance.

APPENDIX IV.

OXIDUM FERROSO-FERRICUM.

In the foregoing Essay I have endeavoured to draw the reader's attention to the different states of saturation with oxygen observable in the mineral kingdom in iron, and in mentioning refractory iron ore, I have stated that, agreeably to my experiment, it consists of oxidum ferroso-ferricum. I shall here state this experiment, together with some observations which may be of utility in mineral analysis.

Proust first remarked that iron ores, which are usually considered to be protoxide, contain a portion of oxide of iron by no means inconsiderable; and he showed that common Prussian-blue contains both protoxide and peroxide in the form of two distinct bases. As Proust only expressed himself respecting iron ores incidentally, his idea was either not noticed or not received, particularly as there was no reason to suppose any chemical combination between two different degrees of saturation with oxygen of the same radical.

From a phenomenon which took place in my first experiments respecting the chemical proportions, particularly my labours with iron, I was led to conclude that such combinations must occasionally exist, and I expressed a conjecture that, as the white precipitate obtained from the salts of protoxide of iron with caustic alkali becomes blue in the air, this blue oxide must contain a combination of peroxide and protoxide, and that an increasing quantity of oxide was the cause of the green colour which the precipitate takes before it becomes completely yellow in the air.

Some time afterwards Gay-Lussac (in Annales de Chimie, Nov. 1811) published that he had discovered a new degree of oxidation in iron, which, according to his account, could be obtained when the steam of water was passed over red hot iron, or when iron was heated in an open fire. According to Gay-Lussac's analysis it ought to contain 27·41 per cent. oxygen, or 37·8 parts oxygen for 100 parts iron. He adds that this oxide possesses the property of forming peculiar salts, and that it is found produced by nature in Swedish iron ore.

That such a degree of oxidation cannot exist we already know from the doctrine of chemical proportions, (which neither M. Gay-Lussac nor his proselytes ever dreamed of, though we have to thank him for one of the most important discoveries connected with this doctrine.) I have already shown in another place, that what Gay-Lussac considered as salts of this new oxide were nothing but double salts of peroxide and protoxide, resembling Prussian-blue, and that these oxides can alone be distinguished from all other bases which have a stronger affinity to the acid than the oxide, but weaker than the protoxide.

That M. Gay Lussac was mistaken in his conjecture that the oxide which is formed when iron in a heated state is oxydized at the expense of steam, without the assistance of atmospheric air, was a new oxide, we may be convinced from the admirable experiment of Bucholz, (Journal für die Physique, Chemie, und Mineralogie, published by Gehlen, 3 B. 710,) in which 100 parts of the oxide produced in this manner, oxydized by means of nitric acid, gave in three different trials 110 parts red oxide; which is a proof that it must have been absolute protoxide free from peroxide. My experiments have coincided in every respect with that of Bucholz, and I have besides found that if oxide of iron is put into a glass tube, and this is heated, and afterwards a stream of hydrogen gas is conducted into it, the oxide of iron is reduced not to the conjectured oxide of Gay-Lussac, but first to protoxide, and afterwards, if the experiment is longer continued, to metal, which in this manner we can obtain in an absolutely pure state as well as in its finest mechanical division.

There remained now the important question: as our iron ores are magnetic, they evidently contain both protoxide and peroxide; in what condition is the latter found in them, and in what quantity?

1. A pure magnetic iron ore (from Slogbergskölen and Norra drawn in Grangesfället,) was pulverised thoroughly, and the earth separated from it. The heavier powder of iron ore was again pounded to an exceeding fine powder in a porphyry vessel, afterwards mixed with water and the iron powder drawn from the water by a magnet, and as it was taken up it was again

put into pure water, and shaken about in it to separate every possible particle of adhering earth, and this was repeated again in fresh water till it ceased to be in any wise troubled by it. The iron ore obtained in this manner was dried and freed from all moisture. As the iron ores in this place frequently contain phosphate of iron, a portion of the ore was digested with diluted nitric acid, which was afterwards evaporated till it became dry, and yielded only a little oxide of iron without any symptom of phosphate of iron.

Five grammes of this iron ore, dried in a heat sufficent to fuse tin, were dissolved in concentrated muriatic acid, after which it was mixed with nitric acid, and allowed to boil for some time: in the beginning it yielded a little nitrous gas with ebullition. The solution was strained, and it left on the filter a grayish powder, which, after being heated to redness, weighed 0·121 grammes. It was a substance quite foreign to the constituents of the iron ore.

The strained solution was precipitated by caustic ammonia in sufficient abundance, and digested in it; the oxide was separated by the filter, well washed, dried and heated to redness, when it weighed 5·061 grammes. It was in the slightest degree attracted by the magnet.

The boiling liquid precipitated by the ammonia, when saturated with caustic potash, gave no precipitate. The oxide of iron, on an accurate inspection, was found to be completely free from manganese.

When we deduct from five grammes of iron ore employed 0·121 of foreign matter, there remains 4·879 of pure iron ore, which afterwards takes 0·181 grammes oxygen to form 5·061 grammes of oxide of iron. These 5·061 grammes of oxide of iron contain 3·506 grammes of metallic iron. By an easy calculation we thus find that in the ore examined, there was

Iron..........	71·86	100·00	693·64
Oxygen	28·14	39·16	271·63

Now this number is not in any wise the multiple corresponding to the quantity of oxygen the iron takes in its remaining degrees of oxidation; for if we do not wish to suppose that the protoxide of iron contained four particles and the oxide six particles of oxygen, so that this medium degree would contain five particles of it, (which however is a multiple hitherto unknown for all bodies,) then the 100 parts iron must have been combined with 35·75 parts oxygen, and not with 39.16 parts. Hence this iron ore must be a combination of the two oxides.

The most simple proportion in which these two oxides can be supposed combined is that where the peroxide contains thrice the oxygen and twice the iron of the protoxide. In such a combination the composition is

Iron................	71·8	100·
Oxygen............	28·2	39·29

which therefore conincides as nearly with the proportion found as we can expect in any experiment. The iron ore itself thus consists of almost precisely 69 parts red oxide and 31 parts protoxide.

2. Magnetic iron ore (from Mohrgrufvan at Riddarhuttan) was examined in like manner and with similar precautions, as those mentioned above.

Five grammes of this ore left 0·119 grammes earth, and exceeded 5·069 grammes of oxide, on which the magnet had not the smallest effect, and according to the preceding calculation it gave

39·2 parts oxygen for 100 parts of iron; whence it follows that this magnet was absolutely the same combination of peroxide and protoxide with the foregoing ore.

We must not, however, suppose that these two oxides always appear in the mineral kingdom combined in the same proportion, especially as they are to be met with in the form of salts like arseniates, phosphates, siliciates, &c. because we possess examples that they can exist in salts in various proportions; for example, in *Prussias ferroso-ferricus*, (Prussian-blue,) and in *Subprussias ferroso-ferricus*, (subprussiate of iron,) in which the proportion of peroxide of iron to the protoxide is not the same. We must therefore never assume *oxidum ferroso-ferricum* as a determinate basis, but must always endeavour to determine the quantity of the protoxide, especially as it may occasionally happen that the latter constitutes the unity or fundamental particle of the mineral, which we in vain seek for among the other ingredients.

Unfortunately however this determination is so extremely difficult that at present we are compelled to consider it as altogether impossible. It will not perhaps be possible to effect it till the analyses are brought to such a degree of perfection, that what cannot be solved by direct experiments may sometimes be sufficiently determined by calculation.

In the course of my experiments respecting chemical proportions, I imagined I found that a great number of oxides of the same radical which are to each other in the proportion of oxygen that they contain $= 1 : 1\frac{1}{2}$, possess the property of combining, while I know no examples of any combinations between oxides in which the oxygen is $= 1 : 2$. Thus, for example, the nitric acid enters into combination with nitrous acid, peroxide of cobalt with the oxide of cobalt, (Proust's and Thenard's green oxide of cobalt,) peroxide of uranium with the protoxide of uranium, &c. According to all appearance, the red oxide of manganese, which gives an amethyst colour to many minerals, is a similar combination of peroxide and protoxide, an *oxidum manganoso manganicum.*

It is certain that it is of the utmost importance to mineralogy, that the few cases of this nature should be completely ascertained.

APPENDIX V.

ANALYSIS OF GLUCINA.

Pure Glucina was dissolved in sulphuric acid in excess. The salt was evaporated till the acid began to be expelled, after which it was freed from the adhering acid by washing it with alcohol. The sulphate of glucina obtained in this manner was dissolved in water, and was precipitated first by carbonate of ammonia, with which it was digested so long as the ammonia continued to fly off. The solution was filtered, and the earth well purified and heated to redness. It weighed 0·553 gramme. The liquid from which it had been precipitated was treated with muriate of barytes. It gave precisely five grammes of sulphate of barytes, corresponding to 1·72 grammes of sulphuric acid. This salt consisted therefore of

Sulphuric acid........	75·67	100·00
Glucina..............	24.133	32·15

As many circumstances induced me to consider it as an acidulous salt, I mixed a concentrated solution of it with carbonate of glucina free from ammonia, and digested them together; by this means I obtained at top a gum-like solution and the carbonate was decomposed, forming, while the water was boiling hot, an insoluble mass viscid and soft, but when the temperature was lower it became hard, transparent, and brittle. In its appearance it resembled gum, and when I endeavoured to dissolve it, the whole was decomposed into a soluble and an insoluble salt.

The gummy-like liquid was divided into two portions; (α) the one was mixed with pure water as long as any precipitate appeared, after which the solution was filtered, and what came through was first decomposed by carbonate of ammonia, and afterwards by muriate of barytes. It gave 1·001 grammes glucina, and 4·549 grammes sulphate of barytes corresponding to 1·56 grammes of sulphuric acid. Hence this salt consisted of

Sulphuric acid..........	60·926	100·
Glucina	39·074	64·1

or the acid was combined in it with twice as much basis as in the preceding.

(β) The portion of the salt not mixed with water was heated over a spirit lamp till it became dry, when it resembled exactly alum, or sulphate of alumina when deprived of its water of crystallization, and it left a spongy, bulky, and shining mass. After it gave out no more water over the flame of a spirit lamp, it was exposed to a red heat in a wind furnace as long as it lost any part of its weight, 2·5 grammes of this salt left 1·24 grammes earth: hence the salt consisted of

Snlphuric acid.........	50·4	100·
Glucina	49·6	98·4

or the acid in it was combined with three times as much basis as in the first analysed salt.

As no subsulphate can exist in which the acid is combined with twice as much basis as in the neutral salt with the same basis, it is clear that the first of these salts is an acid salt, the second neutral, and the third a subsalt; but in such a manner that the acid in it contains twice the oxygen of the base, which is the first example that has hitherto been found of such a salt, and presupposes either that the sulphuric acid, like nitric acid, arsenic acid, and chromic acid must contain six volumes of oxygen, in place of three, the number hitherto adopted, or that the glucina contains three volumes oxygen, which latter is also probable from other circumstances.

The subsalt which is precipitated when the last named substance is decomposed with water gives, when heated to redness, 53·2 per cent. earth, and emits first water and afterwards sulphuric acid. From an accident the heat in my analytical experiment in this case came to be too high, so that the acid escaped with the water. I have not since had an opportunity of preparing a fresh quantity of this subsalt: but the earth which remained coincides in quantity with what it ought to be if this salt resembles the usual subsulphates, in which the acid, the base, and the water of crystallization contain an equal quantity of oxygen. Such a salt consists of

Glucina	53·14
Sulphuric Acid	28·11
Water	18·75

If therefore 100 parts sulphuric acid neutralise 64·1 parts Glucina, this must contain 19·96 parts oxygen, and the earth would thus be composed of

Glucina	68·861	100·
Oxygen	31·136	45·22

That I might not altogether depend on the analysis of sulphates, I dissolved glucina in muriatic acid. It gave a crystallizable salt with excess of acid; but when the acid was expelled, and the subsalt began to be formed, it yielded only a gummy like mass. This was dissolved in water, filtrated from the subsalt, and precipitated first by carbonate of ammonia, and afterwards by nitrate of silver. I obtained 0·626 gramme glucina, with 3·392 grammes of muriate of silver, corresponding to 0·6465 gramme muriatic acid; the salt therefore consisted of

Muriatic Acid	50·865	100·
Glucina	49·135	96·6

But if 96·6 glucina contain 29·454 parts oxygen, then 100 parts earth contain 30·5 parts oxygen, which accordingly approaches very nearly to what we have above stated.

With respect to the number of volumes of oxygen, it appears that the glucina contains three. I ground this conjecture on this, that both sulphuric acid and alumina, which seem to contain three volumes of oxygen, combine with glucina in such proportion, that they hold twice the oxygen of the latter, a circumstance that would not take place if it held twice or four times the oxygen. The volume of glucina weighs therefore at the minimum 681·3, (according to the experiment on the muriate,) or at the maximum 683·63, (according to the analysis of the sulphate.) It is not so easy to determine which of these numbers is the most accurate.

THE END.

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ost scrupulous exactness. We
ed upon 0·25 kilo. (about nine
the net weight, a quantity
o give all the indications re-
large scale.

tals, previously weighed sepa-
re placed in the crucible and
d the melted mass run into a
ould, which gave a bar of
(about four inches) long, by
$\frac{4}{10}$ths of an inch), and a slag
t. diameter, by about 0.015 met.
1 $\frac{4}{10}$ths by $\frac{6}{10}$ths in.)

bservations resulting from an
n of the alloys obtained, have
t the same time to the nature
rance of the bar, as well as
he slag. These observations
haracterize the principal pro-
the compound metals. These
ed by careful and precise re-
n the tenacity, malleability,
c. &c., the exact appreciation
can only be established by
he fusion of the metals, and
f mixing them in the crucible,
at first sight, it may appear,
re care than is usually given.
of all kinds are very difficult
when the metals, as zinc and
r and lead, for example, have
ntipathy for affinity. In such
is only after much care and
at we are enabled to obtain
homogeneous character, pre-
one mould the body and the
lloys reunited after the first
e will point out the precau-
ssary to be taken, to form as
mixture as possible, in de-
rther the principles inherent to
s of combinations; but, as a
sition, we at present lay down
ng principles:—

elt the least fusible of the
which the alloy is to be com-
heat the metal after its fusion
uires such a temperature that
the introduction of the other
thout an instantaneous and
oling.

troduce, when once the first
fusion, the metals which are to
loy, in the order of their infusi-
atever may be the proportions
als, it is always indispensable
t the most refractory metal, and
when it enters into the compo-
he alloy as the principal base.
ity of this metal gives, indeed,
e of the temperature necessary
the alloy. In first charging
e with a fusible metal, it is
exposed to much oxidation: it volatilizes, and the crucible is broken in waiting for the proper temperature for receiving, without immediate cooling, the less fusible metal; the loss is much greater than it otherwise would be, and the proportions of the alloy sensibly modified.

"3.—Heat, in the flame of the furnace, the metals to be afterwards introduced to form the alloy, in such a manner as to elevate their temperature to a certain point, before passing them into the crucible, in order that there should not be so great a difference between their temperature and that of the metal previously in the crucible. This is especially useful when a volatile metal like zinc has to be added, which, if melted too suddenly, often cracks the crucible.

"4.—Stir well, after the introduction and fusion of each of the component parts of the alloy; cover the crucible, and give a good stroke of the fire, the stronger in proportion to the greater difficulty with which the metal enters into fusion.

"5.—In the case of alloys containing a large proportion of zinc, cover the surface of the metal with a thin layer of charcoal powder. This precaution is not necessary, unless the alloy contains a metal requiring a high temperature for its fusion, as, for instance, copper or iron, or when the proportion of zinc added to the melted mass is such that it is not necessary, after its addition, to continue the heat, and the running into moulds may be immediately proceeded with. For alloys containing tin, a layer of charcoal is apt to convert a part of the metal into dross; it is better, therefore, to employ sand.

"6.—Stir the melted mass vigorously at the moment it is run into the moulds, and stir during the running out, if possible; for this purpose a rod of white wood should be employed, taking care to avoid the use of iron, which renders the alloys dry and strawey, and sometimes modifies their nature.

"7.—Carefully clean the crucible after each operation, as well for the purpose of rigorously preserving the composition of the alloy, as also for promoting the fusion of the metals.

"Such are the general conditions requisite to be attended to in the preparation of alloys, and which, if followed, will be found to be productive both of economy and good results."

"In practice it is generally found that a minute quantity of old alloy introduced into the new, imparts to the composition

ll the character of homogeneity exhibited
y a re cast.

" In the ternary or quaternary alloys
rmed of copper, zinc, tin, and lead, it is
und better, first, to mix together the most
sible metals, such as zinc, tin, and lead,
nd then to combine the alloy thus
ade with the copper, in the proportions
onsidered as the most favourable, and to
mploy these first alloys to form the last
ombination, which will thus be possessed
f superior qualities over an alloy com-
osed by the mixture of all the metals
ogether.

" Nevertheless, the alloys of all kinds,
lthough much more simple and econo-
nical, are not sufficient in every case for
he requirements of industry, and are not
o good as the alloys which have been
e-cast. It is thus that castings of bronze
nd of brass of the first fusion, give at the
econd casting, when the proportions had
een good in the first place, a much
reater resistance, a better grain, a metal more sound and at the same time more easy to work than that obtained by the first fusion.

" When we run the metal into moulds, the alloys of all kinds (we are still speaking of those of which copper forms a component part) produce a metal, it may be less subject to fractures and shrinkages than old alloys, but giving a surface less clean, and a grain less compact, and less easy to work. These alloys besides flow less freely, and do not afford castings with so good a surface,—inconveniences which are of consideration with regard to bronzes and ornaments, but which are not of importance for parts of machinery in general industrial purposes.

" In general, the oftener a metal is melted, the more it loses of its primitive qualities. Iron which has undergone several fusions loses some of its softeness and firmness and becomes harder and more brittle. Copper several times melted takes a finer grain and becomes more tenacious; it is the same also with zinc, tin, and lead. These two last are purified and improved in quality by a second fusion, but this advantage is lost if the re-melting be carried farther.

" This depreciation is due to new combinations which are formed during the recasting,—combinations entirely dependent on the manner in which the operation is conducted. Oxidation by the fire and by the air, and the presence of iron which it is almost impossible to remove during fusion, are the principal causes which produce the depreciation above indicated. These causes act with still greater energy
when applied to alloys re-melted,
lose their primitive proportions
the differential influence of waste,
is almost impossible to re-establi
primitive value whatever care n
taken. The first series of experim
which we have to render an a
comprehends the alloys of coppe
tin, and lead.

" It is the most important seri
practical point of view and is sub
as follows :—

1st Alloy	Tin.	Zinc.	
2nd "	Tin.	Lead.	
3rd "	Tin.	Zinc.	Lead.
4th "	Zinc.	Lead.	
5th "	Copper.	Tin.	
6th "	Copper.	Zinc.	
7th "	Copper.	Lead.	
8th "	Copper.	Tin.	Zin
9th "	Copper.	Tin.	Zin

" We shall now proceed to point
most striking characteristics of th
subdivisions, and to follow the e
tion of each of them by general c
tions on the whole of the expe
giving a *résumé* of all the principal
arising from the various comb
between these four metals.

" The metals employed in the p
tion of the alloys which will no
under review, were all selected
purest and best quality found in t
ket, and had all undergone the firs
Their density after fusion was
lows :—

Copper	8.675
Zinc	7.080
Tin	7.250
Lead	11.300

" These densities will serve as
tions in making comparisons w
densities of the alloys to be h
spoken of."

(*To be continued.*)

BERZELIUS.

We last week recorded the deat
celebrated Swedish chemist, Berz
the 69th year of his age. He h
for a long time in declining healt
although his death will not hav
Europe by surprise, there will be
feeling of grief for so great a los
century which has produced a
number of distinguished chemis
perhaps of any other class of
science, Berzelius stood out as
the first magnitude. If, perh
younger students of chemistry
some measure lost sight of him,
the brilliant researches of modern
chemists, it must not be forgot
the patient labours and sagacious
gations of Berzelius have done

foundations of organic chemistry
ose of any other chemist. To him
han to any other man belongs the
of applying the great principles
had been established by Dalton,
Wollaston, Gay-Lussac, and him-
inorganic chemistry, to unfolding
s which regulate the combinations
g the structures of the animal and
le kingdoms.

to the honour of Sweden that
us is only one of a number of her
hom the cultivation of natural
has led from poverty and obscurity
highest dignities and emoluments
edby the State. Of humble parent-
nd beginning life with limited
es, the successful cultivation of
try procured for him, not only the
and admiration of the world, but
sition and consideration in his own
y which the man of science has a
o claim, and which it is the privi-
sovereigns and states to bestow.

elius was born in the village of
sunda, in the canonry of Linkogring,
othland, on the 29th August, 1779,
t Linkagring on the 20th of August
ten erroneously stated in the many
of him. His father kept the
school in the village where young
us was born, and there he appears
received his early education. At
of seventeen he commenced his
at the University of Upsala, hoping
lify himself for the medical pro-
At this time, although Sweden
boast of having produced a Berg-
and a Scheele, the more brilliant
of Linnæus had given to natural
such an impetus that che-
was scarcely regarded by the
l student. It is true that Afzelius
s a nephew of Bergmann, and then
he Chemical Chair at Upsala, had
ed some very creditable chemical
s; but his health was bad and he
isted by Ekeberg, who, though a
analyst, yet wanted the energy and
qualifications for a successful
The lectures on chemistry were
d no experiments were performed.
unpromising circumstances were
y likely to produce a great chemist,
y seem to have developed the
of Berzelius. Prof. Johnston gives
us' own account of the influences
situation. The students were al-
to work in the laboratory once a
"Berzelius, like the rest, went to
oratory soon after he had com-
his chemical course, and asked
peration. The first that was given
him was to form colcothen of vitriol (crocos mentis) by heating sulphate of iron in a crucible, 'Well,' says he, 'every servant can do this. If this be all I am to learn I may as well stay away.'—'Oh, but,' replied Afzelius, 'your next operations will be more difficult.' Accordingly, when he asked for a second operation, he was instructed to prepare caustic potash by burning cream of tartar in a crucible. 'This so disgusted me,' says Berzelius, 'that I vowed I would never ask for another operation. Still I frequented the laboratory; and at the end of three weeks found myself attending regularly every day, though I had no right to do so, and Afzelius could have turned me out, yet I was allowed to return and operate and break much glass,—while Ekeberg especially was much annoyed that I never asked a single question.—For,' he adds, 'I liked better to seek for information from reading and thinking and experimenting than from men who, having little experience themselves, gave me, if not evasive, at least unsatisfactory answers regarding phenomena they had never themselves observed.'"

In the year 1798 Berzelius passed his philosophical examination as preparatory to the final one for M.D. At this time he left the University; and in 1799 we find him assistant to a Dr. Hedin, a superintendent physician of the mineral waters of Medevi. The composition of these waters attracted the attention of Berzelius, and his first published essay was a dissertation in conjunction with Ekeberg on the mineral waters of Medevi. He underwent the examination for a licence to practice medicine in 1801, and graduated at Upsal on the 24th of May, 1804. On leaving Upsal, Berzelius repaired to Stockholm; where he became assistant to Andrew Spaurnau, who sailed with Cook in one of his voyages round the world, and was then professor there of medicine, botany, and chemical pharmacy. Spaurnau died in 1806,—and Berzelius by his inaugural dissertation on galvanism and other papers had already obtained for himself a sufficient degree of confidence to be appointed his successor. Although this chair embraced a very wide range of subjects, as was frequently the case with Swedish chairs at that time, Berzelius more especially devoted himself to chemistry. It does not appear, indeed, that he gave any lectures on botany except at the Military College of Carlberg, where he also held an appointment as lecturer. At first he was not more successful in teaching chemistry than his predecessors ; but having received a hint from Dr. Marcet of London that chemical lectures should be illustrated by experiments, he adopted this plan, and likewise abandgned the old practice of reading lectures. He used to express himself strongly on the inutility of merely reading lectures. Although he first adopted Dr. Marcet's experiments in his class-room, he soon so far improved upon these that his own became a model for the chemical class-rooms of Europe.

During the early period of his resicence at Stockholm he practised the profession of medicine, and in 1807 was mainly instrumental in forming the medical Society of that capital. In 1810 he was made President of the Royal Academy of Sciences at Stockholm ; and in the same year received the appointment of Assessor of the Medical College, and was made a member of the Royal Sanitary Board. At this time, though scarcely more than 30 years of age, he had obtained great reputation as a chemist. He had published a work on animal chemistry containing many original investigations on the fluids of the animal body ; and which was subsequently translated — as, indeed, have been most of his works — into almost every language of Europe. In conjunction with Hisinger, he commenced in 1806, the publication of a periodical work entitled 'Afhaudlingar i Fysik, Keim, och Mineralogi,'—which contained a series of papers by himself, constituting some of the most valuable contributions that had yet been made to analytical chemistry. His labours were regarded as of so much importance, by the Royal Academy of Stockholm, that that body decreed him, in 1811, 200 dollars yearly for his chemical researches. In 1812, Berzelius visited England, where he was most cordially received. In that year he communicated through Dr. Marcet, a valuable paper to the Medico-Chirurgical Society of London, 'On the Composition of the Animal Fluids.' In 1818 he visited France and Germany—countries in which he was better known than in Great Britain, as most of his papers and works were published in the languages of those countries as well as in that of Sweden. In the same year he was appointed Secretary to the Academy of Sciences—a post which he held till his death. In 1831 he was allowed to retire from the active duties of his professorship at the Caroline Institute, but he still held the title of honorary professor. Up to this time he had resided in apartments provided for him at the building occupied by the Academy of Sciences,—where, on the same flo had his study and laboratory, so th could with little difficulty pass fro desk to his crucible, and husban time to the greatest possible e He now, however, moved to a ho his own,—and in 1835 married a dau of the town-councillor (Staats-rathe) pins. In 1837 he received the Grea Medal of the Royal Academy of Stocl —and in 1840 the Diet of Sweden him a pension of 2,000 dollars per a The scientific societies of Europ America contended for the hon enrolling his name amongst their me —and with eighty-eight of these it was connected. Nor was his sove Charles John, behind-hand in recog the most distinguished of his a countrymen. In 1815 Berzelius was a Knight, and in 1821 a Knight mander, of the Order of Vasa. In he received the Grand Cross, and i was made a Baron. The intellige this honour was conveyed to Berzeli the hand of the King ; who wrote h a letter intimating his deep sense merits of the philosopher and expr a hope that in this nomination the would recognize a homage paid to th who had consecrated his life to thos ful researches which had been al recognized by Europe, and which i the glory of Sweden to be able to a priate as the patrimony of one children. This letter was sent to lius on his wedding-day. How few of science have married with a pat nobility on the breakfast table ! S had, however, yet one more ovati her beloved son. In 1843 he had b quarter of a century Secretary t Academy, and on this occasion a fe was given in his honour. The C Prince was in the chair—and a po of the chemist painted by Lieut Lodemark was presented to the Aca

Such was the calm, unruffled, succ career of the deceased philosopher. W that the career of every disciple of sc were as happy ! He who was thus oured, merited it—merited it on ac of his unwearied industry, his clea manly intellect, his noble and an disposition. The diligence with whi worked both in his study and his la tory may be judged of by his syste works and original contributions to sci In addition to the works already tioned, he published a 'Manu Chemistry,' which went through se editions, that of 1841, consisting volumes,—and, we believe, another

has since been published. In 1822,
mmenced the publication of an
. Report on the Progress of the
l Sciences, which has been pub-
every year to the present time.
volumes are the most valuable
of chemical research extant, and
a full report of the discoveries
ve made the period to which they
so remarkable in the history of
ry. From 1806 to 1818, he pub-
with Hisinger the periodical to
we have before alluded; and in
olumes we find forty-seven papers
zelius, all giving an account of
. researches by himself. In addi-
these he has published works on
sm, on analytical chemistry, on
ogy, and a vast number of papers
us Transactions.

name of Berzelius has been too
ely connected with the history of
ry for the last forty years for us
slight sketch to give an adequate
the influence which his discoveries
eralizations have exerted upon the
. To him it is indebted for the
ry of several new elementary bo-
more especially selenium, morium,
ium. He first demonstrated the
ure of silica, and was thus enabled
w light on the composition of a
f interesting mineral compounds
with the metallic oxides. This
ently led to a whole re-arrange-
mineral bodies, and contributed
to the advance of mineralogy.
overy of selenium led him to in-
e its various compounds and com-
em with the sulphurets. These
ations again resulted in his gene-
ms on the nature of the sulphur
d a new classification of the va-
lts. Subsequently, he investigated
pounds of fluorine, and arrived at
the most important and valuable
hat have yet been obtained by the
al chemist.

st Berzelius was writing the first
of his "Manual of Chemistry,'
had promulgated his idea of the
constitution of matter, and Davy
de his great discovery of the me-
ses of the alkalies. These directed
ntion to the laws of combination.
led to institute researches with
t scrupulous care into the com-
roportions of the various elements,
o each its correct number, and was
to obtain results perfectly harmo-
ith theoretical calculations made
ton's laws. He was enabled to
Dalton's law that one atom of one body unites with one, two, or three, &c., atoms of another body, and showed that two atoms would unite with three and with five. He also pointed out the great fact, that two compounds which contain the same electro-negative body always combine in such proportions that the electro-negative element of one is a multiple by a whole number of the same element of the other. He not only gave to the elementary bodies their combining numbers, but introduced the system of symbols, by which chemical labour has been so greatly facilitated. Till the time of Berzelius, organic chemistry was a waste, with here and there an attempt to explain the phenomena of living beings upon chemical principles,—and which from the entire want of experimental foundation was even worse than useless. The compounds found in plants and animals were not supposed to come within the category to which the laws of combination applied. Berzelius was the first to show that these laws could be applied to animal and vegetable products; and in so doing, he opened the way for the discoveries of Mulder, Liebig, Dumas, Boussingault, and others.

As a skilful manipulator, Berzelius has had few equals in the history of chemistry. To this we are indebted for the immense variety, number, and success of his analyses. Many of the analytical processes in use at the present time have had their origin with him.

The personal appearance of Berzelius was that of a strong, healthy man, with nothing in his habits or manners to impress a stranger with a sense of his powers. A chemist who visited him says, "He has nothing of pretence, reserve, or singularity about him; so that his plainness drew from a fellow-traveller of mine, whom he allowed me to introduce to him, the observation 'I would never have thought him the great man he is said to be.'" His attention to strangers was very great, —especially to those who took an interest in chemistry. With these he would frequently spend hours in his laboratory, explaining his methods of working,—and on their departure, he left the impression that he was the honoured party. He was an early riser, and gave the first part of the day to his most important work, whatever that might be. He seldom either wrote or experimented in the evening, leaving that part of the day for reading and social relaxation. He had no particular times for writing or experimenting, when he had a work to finish he would write sometimes for months without performing an experiment,—but if anything of importance occurred to him during his writing requiring, further investigation, he would at once give up the pen and work perhaps for weeks in his laboratory. Few men were more beloved in the city of Stockholm than Berzelius.

Were the mirits of this great chemist less we might not be able to afford to hint at any defects. But regarding him at a distance, he appears to us to have carried his caution beyond the requirements of scientific research. His feelings were conservative, and though constantly going forward to the new, he still clung with tenacity to the old. He was almost the last chemist of eminence that admitted Davy's
theory of the elementary nature of chl
Even after envy and prejudice had
up their opposition, the caution of I
lius withheld assent. In the rece
vances of organic chemistry, also
more especially in its applications
physiology of plants and animals, I
lius has looked on with the eye of a
and withheld to the last his adhes
some of the advanced positions o
department of the science. W
allude to his criticisms on his b
chemists, which were sometimes un
sarily severe, only to add that i
latter years of his life he has been
to say that he regretted having exp
himself in a way that could have
unnecessary pain to others.—*Athen*

Patents Recently Granted.

ENGLISH PATENTS FOR THE WEEK ENDING SEPTEMBER 9TH.

Peter Wright, of Dudley, in the county of Worcester, vice and anvil manufacturer, for certain improvements in the manufacture of vice-boxes, and in the machinery for effecting the same. Patent dated August 31st, 1848; six months.

George Nasmyth, of Ebury-street, Pimlico, in the county of Middlesex, civil engineer, for certain improvements in the construction of fire-proof flooring and roofing, which improvements are also applicable to the construction of viaducts, aqueducts, and culverts. Patent dated September 4th, 1848; six months.

William Wheldon, engineer to Messrs. John Warner and Sons, of Jewin-crescent, in the city of London, brass founders and engineers, for improvements in pumps or machinery for raising or
forcing fluids. Patent dated September 4t
six months.

John Lewis Ricardo, of Lowndes-square,
county of Middlesex, Esq., M.P., for in
ments in electric telegraphs, and in apparat
nected therewith. Patent dated Septemb
1848; six months.

William Edward Hollands, of 73, Regen
rant, in the county of Middlesex, denti
Nicholas Whitaker Green, of No. 15,
place, Chelsea, gentleman, for a new manu
of artificial fuel in blocks or lumps. Paten
September 4th, 1848; four months.

William Losh, of Newcastle-upon-Ty
improvements in steam-engines. Paten
September 4th, 1848; six months.

Henry Smith, of Vulcan Works, West
wich, for improvements in the manufac
railway wheels. Patent dated Septemb
1848; six months.

Patents Recently Expired.

John Joseph Charles Sheridan, of Walworth, chemist, for certain improvements in the several processes of saccharine, vinous, and acetous fermentation. Patent dated September 6th, 1834; expired September 6th, 1848.

William Longfield, of Otley, whitesmith, for an improved lock or fastening for doors and other situations where security is required. Patent
dated September 6th, 1834; expired Septemb
1848.

Henry Shrapnell, of Salisbury, Major-G
Royal Artillery, for improvements in fire-
various descriptions, and in ammunition
purpose of fire-arms. Patent dated Septem
1834; expired September 6th, 1848.

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